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CONTENTS

	Page
Scientific Research and Man-power Problems	129
More Old Cambridge Men. By Prof. F. J. M. Stratton, O.B.E., F.R.S.	131
The Roda Nilometer. By Dr. H. E. Hurst, C.M.G.	132
Universities of the British Commonwealth	133
A Natural History of Bacteria. By Dr. S. T. Cowan	133
Enzyme Systems. By Dr. J. A. V. Butler	134
Biology of Hot Springs	134
Leonardo da Vinci, Artist and Man of Science. By Dr. A. Tindell Hopwood	135
The British Contribution to Television	136
Principles Governing the Amount of Experimentation in Developmental Work. By Dr. F. Yates, F.R.S.	138
Obituaries:	
Prof. H. A. D. Neville, C.B.E. By Cyril Tyler	140
Dr. F. B. Pidduck. By S. C.	141
Colonel W. C. Devereux. By E. A. G. Liddiard	141
News and Views	142
Origin of the Deformation Textures of Titanium. By D. N. Williams and Prof. D. S. Eppelsheimer	146
A New Approach to the Problems of the Spread of Aphids and to Insect Trapping. By Dr. C. G. Johnson	147
Shell-form in the Lamellibranchia. By G. Owen	148
Molybdenum in Relation to Cropping and Livestock Problems under Irish Conditions. By Dr. T. Walsh, M. Neenan and Dr. L. B. O'Moore	149
Principles and Applications of Ion Exchange	150
International Scientific Radio Union	152
British Cast Iron Research Association. By Dr. J. G. Pearce, O.B.E.	153
Lace Research Association: New Centre and Laboratories	154
Letters to the Editors:	
New Procedures for Resolution of Racemic Substances.—H. M. Powell	155
Natural Moisture-content, Porosity and Compaction of Clayey Deposits.—Prof. P. G. H. Boswell, F.R.S.	156
Prominence Activity and the Sunspot Cycle.—Dr. R. Ananthakrishnan	156
Meson Masses.—Dr. K. M. Guggenheimer	158
Evidence for Nuclear Shells from Atomic Mass Measurements.—Prof. Henry E. Duckworth	158
Polarization Field and the Acoustic Modes of Oscillation of Alkali Halide Crystals.—Sir K. S. Krishnan, F.R.S., and S. K. Roy	159
Direct Calculation of Viscosities of Liquids.—M. S. Telang	160
Effect of Drying upon the Absorption Spectra of Hæmoglobin and its Derivatives.—Prof. D. Keilin, F.R.S., and Dr. E. F. Hartree	161
Transaminases for Pyridoxamine and Purines.—Prof. Carolyn F. Gunsalus and Joseph Tonzetich	161
Formation and Breakdown of Pentose Phosphates by Liver Fractions.—Dr. Gertrude E. Glock	162
Glucuronide Decomposition in the Digestive Tract.—C. A. Marsh, F. Alexander and Dr. G. A. Levvy	163
Triosephosphate Dehydrogenase and Glucose-6-Phosphate Dehydrogenase in the Pea Plant.—Dr. Martin Gibbs	164
Glycerol as a Nutritive for *Vibrio cholerae*.—Dr. Deborah Kaplan and Dr. Walter Koch	165
Lepine and Sautter's Disease in Great Britain.—Dr. R. Hadek	165
Hyoid Arch of Rhinobatidæ.—A. R. Hamdy	166
Epidermal Glands in Centipedes.—Gordon Blower	166
'Infra-Red' Brooding and the Crooked-Toe Problem in Chicks.—Dr. D. J. G. Black, J. Getty and T. R. Morris	167
Sulphinylureas and Sulphenylureas.—Frederick Kurzer	167
Unimolecular Chlorohydrocarbon Decompositions.—Dr. K. E. Howlett	168
Chlorogenic Acids in Fruit Trees.—Dr. A. E. Bradfield, A. E. Flood, A. C. Hulme and A. H. Williams	168
The Symmetrical Spherical Top.—G. N. Copley	169
"Library Services in the British Colonial Territories".—Lionel R. McColvin	169
Recent Scientific and Technical Books	Supp. vi

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SCIENTIFIC RESEARCH AND MAN-POWER PROBLEMS

QUITE apart from the fact that it elicited from the Lord President of the Council some indication of the Government's intentions in regard to the Science Centre and the expansion of higher technological education (cf. *Nature*, June 21, p. 1039), the debate in the House of Lords on June 11 and 12 on science and industry is of considerable interest as providing the commentary which the Advisory Council on Scientific Policy might otherwise have been expected to supply in publishing recently the report of its Committee on Scientific Man-power. The debate was initiated by Lord Samuel on a motion asking for a statement on the use made by industry and agriculture of the results of scientific research, and on the Government's policy for promoting the higher education of technologists. Lord Samuel himself commented at some length on the man-power report, stressing particularly the need for a broadly based system of technological education. Lord Woolton, before dealing with this latter question, reviewed briefly the whole Government organization for research, through which some £16,000,000 a year is spent directly on civil scientific research, apart from the £18,000,000 provided by the Treasury for the universities, a considerable part of which is spent in training scientific men. Much of what he said related to the Department of Scientific and Industrial Research, and this part of his speech, as well as further comments in the debate and replies from the Government side, throws some light on the Government's attitude to some disquieting features of that Department's last annual report.

Lord Woolton, after citing examples of substantial returns which had accrued from work under the Department of Scientific and Industrial Research, expressed general satisfaction with the extent of applied research being carried out in Great Britain, though not with the way in which its results are being applied in industry. In asking the Advisory Council on Scientific Policy to review the effectiveness of current arrangements for ensuring that the results of research make their full contribution to the development of the British economy, the Lord President no doubt had in mind some extension of the survey of the organization for research which was carried out by the Select Committee on Estimates in 1947. The Survey Panels which have already been set up to survey the resources and work of particular research associations in relation to the needs of their industries are evidence that the expenditure and efficiency of the Department of Scientific and Industrial Research are being closely examined from within.

A number of comments made during the debate supported this realistic policy, and Lord Falmouth, in particular, pressed for close examination of the vote for research and development under the Ministry of Supply, which now stands at £100,000,000 and has increased by £18,000,000 on last year; this is more than three times the total expenditure

on the Department of Scientific and Industrial Research.

In this context the support given in the Lords debate to the plea of the Advisory Council for Scientific and Industrial Research for action to deal with some of the more urgent items in the Department's building programme is the more impressive. Lord Woolton explained that the construction of a modern tank for shipbuilding tests was delayed not on financial grounds but by design difficulties, and assured the House that the project would go ahead as soon as the design is available. Neither he nor Lord Cherwell replied, however, to Lord Crook and Lord Halsbury or other speakers, who strongly supported the Advisory Council's plea for greater flexibility in regard to the Department's expenditure, and particularly that the Department should be permitted to carry over unspent balances and allowed some increase of expenditure of the order of five per cent until its post-war plans are fulfilled.

On the whole, however, the trend of Lord Woolton's and Lord Cherwell's observations warrants some confidence that the support forthcoming for the Advisory Council for Scientific and Industrial Research in this debate will not be without effect. Nor did the Advisory Council's remarks on the man-power situation in the Department pass unnoticed. Many speakers seemed inclined, indeed, to probe that situation more deeply, and especially the observation in the man-power report of the Advisory Council on Scientific Policy that many of the best science graduates appear to be attracted to employment outside the Government scientific service. Lord Pakenham rather discounted the suggestion that inadequate salary-scales are responsible for the difficulty the Department of Scientific and Industrial Research and the Agricultural Research Council are experiencing in obtaining recruits of sufficiently high quality, and urged that it is rather a matter of prestige and of the removal of any barriers which prevent scientific men with administrative gifts from rising to the highest positions.

More may well depend on the conditions of service than Lord Cherwell seems disposed to concede. Conditions are liable to be more restrictive in Government service and, in the main, those conditions, as regards freedom of publication and the like, may not compare unfavourably with those in industry, as Lord Cherwell suggested. Nevertheless, his reference to freedom of movement between men of science in Government service, universities and industry was not too happily phrased and could convey the impression that such movement is regarded with disfavour generally, instead of being restricted or discouraged only in respect of those who have been working on the most secret subjects in Government service.

While Lord Cherwell's attitude here is right and reasonable, it could have been accompanied by some indication that, on the Government side, it is appreciated that any such limitation, however necessary, is a handicap to the advance of science and to industrial development. Misapprehensions are not removed by brusqueness, and while more attention to general education, as freely emphasized in the debate, may remove a deficiency in the training of scientific men to which the Advisory Council on Scientific Policy directed attention in its fifth report, it will not of itself overcome the reluctance to enter Government service. More attention to the question of status and to like psychological factors appears to be desirable, both from the point of view of recruitment and of ensuring that the best use is made of the services of scientists and technologists and of the results of their work.

Lord Wise referred to the importance of exchange of staff between different institutes and between industry and the colleges of technology, from the point of view of improving standards of training in technology. Government establishments, and notably the research associations of Britain, have their part to play also, and it should be possible for the Lord President of the Council by his policy here to dispel any misgivings that Lord Cherwell's speech may have encouraged. The siting of the proposed new technological university and the choice of the few colleges of technology to be raised to university status should also have regard to the way in which proximity to a university and to centres of industry could foster both exchange of staff and co-operation.

Prof. R. S. Edwards, in a paper in the January issue of *Lloyds Bank Review*, lays much stress on the importance of closer collaboration between universities, research associations and government research establishments, as well as between the universities and industry. He, too, believes that we have still a long way to go before British industry is fully accustomed to the idea of employing university graduates, and that it will be some time before application enjoys the same prestige as pure research. Here, as in his emphasis on the importance of industry being well supplied with men and women capable of understanding the interplay of scientific, technological and market forces, and of framing and executing appropriate policies, he is in agreement with the findings of the man-power committee of the Advisory Council on Scientific Policy, and indeed some of his conclusions and suggestions are more specific.

On this question of co-operation, Prof. Edwards makes three important points. First, referring to the research associations, he stresses the substantial contributions to technological education which such associations could make. Where it is, in fact, being made, he considers it alone justifies support of an association. Financial partnerships between industries and the State on these lines are sound, he urges, provided that there is no pampering, that the negotiation of grants is hard-headed and business-like, that the Government makes sure it gets value for public money, and that it does not keep sickly associations alive too long. It would seem from Lord Woolton's speech that he is already alive to the implications of this view.

Prof. Edwards's second point concerns the universities as well as the research associations. While he considers our research institutions are well adapted to our present needs, he expects the demand for facilities for sponsored research to grow as more

scientists and technologists are employed in British industry and technological competition becomes keener. He believes that the research associations should play a part in meeting this need, and that they could, as an extension to the existing advisory services, develop facilities for sponsored projects which do not clash with their co-operative programme without imperilling the co-operative nature of the associations. The universities also should participate in this field, and Prof. Edwards believes that they could do so, with appropriate safeguards and proceeding cautiously, without endangering either academic freedom or distorting their research programme.

One reason given by Prof. Edwards for advocating such a step, which admittedly is not at present favoured in academic circles, is that an increase in the volume of sponsored projects in the universities would raise the prestige of industrial research and application among young scientific workers and would be an additional source of university finance. In the light of the report of the Advisory Council on Scientific Policy, any measure that promises to break down the reluctance of promising students to enter on a scientific and an industrial career should be considered with an open mind, and Prof. Edwards's suggestion should be noted particularly with reference to research in technological institutions, on which stress was laid by Sir John Cockcroft in an article in the May issue of the *Universities Quarterly* as well as in the House of Lords debate. Prof. Edwards's third point is indeed that there should be closer collaboration between universities, research associations and government research establishments in regard to postgraduate studies. He visualizes, for example, research associations collaborating with the universities and the colleges of technology to provide some of the facilities for postgraduate work, on the meagreness of which Sir John Cockcroft pointedly commented.

Such a measure should supplement, rather than be a substitute for, the more generous provision of means for postgraduate research in the technological departments and the colleges of technology themselves. The possibilities in this direction should be carefully examined as part of the policy for the development of higher technological education. This in itself is an urgent reason for placing the responsibility for technological education in the same hands as are responsible for university education. It is to be hoped that at least the House of Lords debate will bring home to the Government the need for definite action in this respect, and for relieving the Minister of Education of this anachronism in her responsibilities.

It is of course, clear from the circumstances of the speeches in the House of Lords that few new points could be contributed to the discussion of the organization of civil research and the recruitment of scientific workers. Its realistic tone was, however, encouraging, and should help to ensure that a close watch is kept to see that the nation gets a full return from its investment in research, and that financial parsimony does not impair efficiency or hold up essential developments.

MORE OLD CAMBRIDGE MEN

Alumni Cantabrigienses

A Biographical List of all known Students, Graduates and Holders of Office at the University of Cambridge, from the Earliest Times to 1900. Compiled by Dr. J. A. Venn. Part 2: From 1752 to 1900, Vol. 4: Kahlenberg–Oyler. Pp. iv+615. (Cambridge: At the University Press, 1951.) 150*s*. net.

ON looking through this volume one is once more struck by the very high proportion of members of the University of Cambridge during the years 1752–1900 who took orders in the Church of England after leaving the University. This is to be explained in part by the fact that the University was for the greater part of the period closely linked with the Church; but that is not the only reason for the change that is to be found in the proportion of clerical graduates to-day. Careers for university graduates were more limited in range in this earlier period; the Church, schoolmastering, an academic career, the professions of medicine and law, the army, diplomacy, the Civil Service, the Indian Civil Service and the Colonial Service, such business careers as banking and publishing—these covered the chief openings for university graduates. Some men joined their fathers' businesses, but posts in industry and business generally were not offered as a rule to university men.

The biographies of individuals in the book are necessarily short; but a number of interesting facts emerge even from a casual study of the volume. Thus we learn that Prof. Herbert Marsh, F.R.S., Lady Margaret professor of divinity, 1807–39 (and simultaneously Bishop first of Llandaff and then of Peterborough), was the first to give his professorial lectures in English, instead of in Latin. Another divine who made a name for himself was the Rev. T. R. Malthus, F.R.S., known not unnaturally as "Old Pop". Of the Rev. Eward Kempe we are told that he left a ton of unpreached sermons behind him. Schoolmasters include the great flogging master, John Keate, of Eton. Naturally a large number followed an academic life—we will only mention here Prof. George Liveing, professor of chemistry for more than forty years, who died at the age of ninety-seven, James Clerk Maxwell, the first Cavendish professor, and Bartholomew Lloyd, who was incorporated D.D. in 1833 from Trinity College, Dublin. He was then Provost of Trinity, having previously been successively professor of mathematics, professor of natural philosophy, regius professor of Greek and lecturer in divinity. The Army provides Teignmouth Melvill, who earned the Victoria Cross at Isandlwanha in the Zulu War. In diplomacy we will mention two exceptional types: Thomas Manning, friend of Lamb, the first Englishman to enter Lhasa, a great Chinese scholar, and Henry Labouchere, who contracted £6,000 of debt in two years in Cambridge, joined a circus troupe, lived for six months in a Red Indian camp, then entered the diplomatic service, was dismissed for impertinence to Lord John Russell, became an M.P., and then a successful journalist with the *Daily News* and *Truth*.

About ninety Fellows of the Royal Society appear in this volume, of whom some half-dozen happily survive to-day; there is a very marked concentration among the names commencing with 'Mac' or 'Mc'. Among the honorary graduates who were also distinguished in science we may mention the names of

Klein, Le Verrier, Lister, Mendeléeff, and (Sir John) Murray. A great many of the graduates were Fellows of the Society of Antiquaries; for example, the Earl of Crawford, F.R.S., the founder of Dunecht Observatory, who went to Mauritius to observe the transit of Venus in 1874. Others who travelled to study happenings far from Cambridge include James Losh, who went to Paris to study the French Revolution and whose life was saved by Marat, formerly a veterinary surgeon in Newcastle; also three war correspondents—Kinglater for the Crimean War, Lockhart for the Franco-Prussian War, and E. F. Knight, a war correspondent in some dozen campaigns.

Various forms of sport and athletics figure among the records: the Hon. Ian Keith-Falconer, the most famous cyclist in the 'eighties, "Black" Morgan, who was the first (with Leslie Stephen) to climb the Jungfraujoch, F. E. Lacey, secretary of the M.C.C., Jack Mytton, the famous horseman, the Hon. George Lambton, trainer of many winners in classic races, John McGregor, of the 'Rob Roy' canoe, John Mackinnon, who played for England against Australia in 1879 and was presented with a bat by his clansmen on his ninety-eighth birthday, and we may add C. F. L'Oste, who went up in an aeroplane on his 103rd birthday, at which age he had never consulted a doctor.

In conclusion, a few names may be mentioned for the human touches in their biographies. W. J. Locke, the novelist, started as a graduate in mathematics, "an utterly futile and inhuman subject". John Mortlock was nine times Mayor of Cambridge. In contrast to J. C. Neild, a miser who left £500,000 to Queen Victoria, was Walter Scott Lockhart, described by his father as a "human financial sieve". Others who earned nicknames were John Lupton, "the pocket Hercules", Richard Martin, "Humanity Martin", H. H. Norris, "the Bishop-maker". Edward Meade-Waldo was one of the very few trained naturalists who claimed to have seen a sea-serpent, Sir William Molesworth, Bart., was sent down for challenging his tutor to a duel, and Edward Maitland claimed to have been previously Marcus Aurelius and St. John the Evangelist, "hence the mention of boiling oil was inexpressibly painful to him".

F. J. M. STRATTON

THE RODA NILOMETER

Le Mikyâs ou Nilomètre de l'Ile de Rodah
Par Kamel Osman Ghaleb Pasha. (Mémoires présentés à l'Institut d'Égypte, Tome 54.) Pp. xvi+182+46 plates. (Le Caire: Imprimerie de l'Institut Française, 1951.)

THIS book gives a detailed description and history of the Roda Nilometer or river gauge, with an account of the extensive repairs and restoration undertaken in 1938.

The author was officially in charge of the gauge for many years as inspector-general of irrigation in Upper Egypt and later as under-secretary of state in the Ministry of Public Works, from which he retired some years ago. It was owing to his efforts that the very thorough restoration of the gauge, estimated to cost about £36,000, was carried out under his supervision.

The Nilometer is situated on the southern edge of Cairo and consists of a large square well walled in stone with a marble column in the centre carrying a scale divided in cubits, and is connected with the river by subterranean passages. It was built about A.D. 861 and succeeded earlier gauges near the same spot, and a still earlier one some miles upstream near Helwan. Records of flood and low-stage levels on these gauges have come down to us beginning in A.D. 622, twenty years before the Arab invasion of Egypt. There have been Nilometers from very early times; but very little information about river-levels can be derived from those, other than that at Roda, which is the most important of all. It was in charge of an official, the Sheikh el Mikyas, whose duty it was to observe the water-level and in flood-time announce to public criers daily the amounts by which the river had risen. If the flood did not reach a certain level much land would go unwatered and there would be famine. At a certain higher level irrigation was assured; and also the taxes to the government. From the building of the present Nilometer until recent times the post of Sheikh el Mikyas has remained in the same family, and the last holder, who died in 1947, inherited the post through his grandmother, who was of the original family—surely a record for length of tenure of an official post in one family.

The book describes very fully the construction of the Nilometer and the changes in it which have taken place, including the recent restoration. In this the marble pillar was removed and the well was cleared of silt right to the bottom. This clearance uncovered work which was previously unknown and revealed the doubtful nature of the foundations. In order to preserve the Nilometer it was necessary to place a solid floor underneath it and surround the well with concrete. The well is now dry and cut off from the river, so the Nilometer should remain as an ancient monument for an indefinite time. The Nilometer has not been in use since 1887, and the river-levels have been observed on a metric gauge near by on the river wall.

Many excellent plates show the details of construction of the Nilometer and the discoveries made during the recent restoration. The author has collected a great mass of references to the Nilometer from the writings of old Arab scholars and of medieval and modern visitors to Egypt. The work of doing this must have been immense. This leads to what is perhaps the most important part of the book, the discussion of the recorded levels. The earliest records of gauge readings are lists compiled in the fifteenth century by three Arab writers; but the sources from which they were derived are unknown. These end with the year A.D. 1470, and after that the sources are a number of writings by Arabs and foreign travellers, and the records are much less complete. In relating these to present-day levels there are many difficulties due to the use by the chroniclers of the Moslem year, which is lunar, and, more important, the various repairs and changes which have been made to the column. In view of the researches of Ghaleb Pasha it will be necessary to revise the list of readings converted to a metric scale, which has been used in all investigations of the past forty years. This will affect the numerical values but not the most important conclusions derived from previous studies of the records. Taking a general view one may say that although the recorded readings contain many sources of error, and naturally have not the precision of modern observations, nevertheless they are probably as reliable as statistics collected to-day about

less well-defined phenomena such as health or social conditions. They can be used with suitable precautions for such investigations as the search for periodicities or the probability of occurrence of high or low floods.

Ghaleb Pasha is to be congratulated on having collected and published this great mass of information relating to the Nilometer. H. E. HURST

UNIVERSITIES OF THE BRITISH COMMONWEALTH

The Yearbook of the Universities of the Commonwealth, 1952

(Published for the Association of Universities of the British Commonwealth.) Twenty-ninth Issue. Pp. xxxii+1661. (London: G. Bell and Sons, Ltd., 1952.) 42*s*. net.

THE "Yearbook" of the Association of Universities of the British Commonwealth has established itself as a standard work of reference on both general and specific academic matters pertaining to the countries of the British Commonwealth, and such a comprehensive single volume is invaluable not only for universities and colleges but also for government departments, business houses, clubs, schools, libraries and the public generally. It is, in fact, the principal publication of the Association; but it is important to note that it covers Commonwealth university institutions and does not confine itself merely to member institutions of the Association.

This twenty-ninth edition is the largest ever published. The "General Information" sections of most university entries have been expanded, and four new appendixes have been added dealing respectively with United Kingdom degree abbreviations, Commonwealth studies in the United Kingdom, international university organizations, and a select bibliography of books on university topics. A further innovation is an introductory account of more than three pages in the section on the British Colonies, which has been prepared by the secretary of the Inter-University Council for Higher Education in the Colonies. Other changes, recorded for the first time in this edition, are as follows: Rhodes University College and Potchefstroom University College for Christian Higher Education, respectively, become Universities of the same name; entries are recorded for the three Indian Universities of Gujarat, Karnatak and Roorkee, and in Pakistan for the University of Peshawar; and entries are recorded for two additional Colleges recognized by the National Conference of Canadian Universities, namely, Carleton College and the Royal Military College of Canada. Finally, this edition now incorporates a date at the head of each university entry showing the time at which the information relating to the entry was compiled; this is certainly a very welcome piece of information.

The general contents of the book follow much the same lines as the previous edition. After a general introduction, the various universities and university colleges of the Commonwealth are listed, starting with the United Kingdom, then each Dominion in turn, and finally the Colonies. This section covers four-fifths of the book; there are the lists of staff (about 25,000 names), general information on each institution and events during the past year. The remaining part of the book consists of ten appendixes, an index of names and a general index. The appendixes cover respectively the following topics: qualifications for admission to a first-degree course in a British university; postgraduate awards tenable in the United Kingdom; postgraduate awards tenable overseas; students from other countries in British universities; degree abbreviations (United Kingdom only); Commonwealth studies in the United Kingdom; universities of the Republic of Ireland; Anglo-American academic relations; international university organizations; and a short bibliography.

A NATURAL HISTORY OF BACTERIA

Bacteria

By Dr. K. A. Bisset, assisted by F. W. Moore. Pp. viii+123. (Edinburgh and London: E. and S. Livingstone, Ltd., 1952.) 20*s*. net.

THE ancestral tree of bacteria that Dr. Bisset has drawn is based primarily on morphology; but, as he says in his preface, "it is in reasonable accordance with the parallel conception of evolution by loss of synthetic power". He postulates that the simple cell from which others have evolved is spiral in shape and aquatic in habitat; progress has occurred with an ability to survive in a terrestrial environment, and the development of a reproductive process that relies on airborne spread. Primitive bacteria are Gram-negative; evolution is shown in the development of the Gram-positive state. Starting with the simple spiral-shaped cells, the tree has four main branches. The first includes the Gram-negative rods and specialized aquatic forms; the second the chain-forming Gram-positive spheres and rods; the third those Gram-positive cells with a branching habit; and the fourth the order Flexibacteriales. Between the second and third branches are the packet-forming cocci. In more formal terms the class Bacteria is divided into four orders: Eubacteriales, Actinomycetales, Streptomycetales and Flexibacteriales; of these, Eubacteriales forms the first two branches of the ancestral tree; the second and third orders form the third branch.

Ordinary morphological characters only divide microscopic organisms such as bacteria into a limited number of groups of ordinal or family rank; further subdivisions into genera and species are usually made on physiological differences. Dr. Bisset has applied his work on the cytology of bacteria to the problem and has made use of finer differences in cell structure in his outline classification. This has both advantages and disadvantages: it takes morphology to a lower rank, but it demands unfamiliar, though not difficult, techniques of the systematist. The result is a classification with which few would quarrel except on points of detail.

In a book of this size it is impossible for the author to do justice to his ideas on the classification of so large a group as the bacteria, and many of the chapters are too brief to be highly informative. There is unfortunately only a brief reference to his interesting and controversial finding that strains of *Rhizobium* species from wild legumes produce resistant endospores; in this the strains differ from the better-known species which grow in symbiosis with cultivated crops. The development of his thesis that the

Rhizobia are related to the *Bacillus polymyxa* group would have made most interesting reading. Two often repeated misstatements that seem to owe their survival to plagiarism should be corrected in a later edition; they are the reputed decolorization of *Mycobacterium smegmatis* by alcohol, and that sporing bacilli are among the commonest airborne contaminants, a statement disproved by day-to-day experience in the laboratory and by air sampling.

In this book Dr. Bisset has given us the hors d'œuvres; we now look forward to a more substantial meal in the form of a fully documented manual on the natural history of bacteria.

S. T. Cowan

ENZYME SYSTEMS

Enzymes and Enzyme Systems

Their State in Nature. Edited by John T. Edsall. (Memoirs of the University Laboratory of Physical Chemistry related to Medicine and Public Health, Harvard University, No. 1.) Pp. xiii+146. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1951.) 18*s*. net.

THIS volume is the first of a series of memoirs of the University Laboratory of Physical Chemistry related to Medicine and Public Health, Harvard University, and is a record of a symposium held in July 1949 on the state and nature of proteins and protein enzymes. It is only twenty-five years since J. B. Summer crystallized the first enzyme, urease, and demonstrated its protein nature. Since then a considerable number of enzymes have been crystallized, and, as Prof. J. T. Edsall remarks in the preface, "the generalization—'no enzyme without protein'—appears established as one of the most widely based inductive rules in the field of biochemistry". There is no doubt that very large numbers of protein enzymes occur in Nature and that in numerous cases they can be obtained in a relatively pure and crystalline state in which they can be studied as chemical individuals. Something having been found about the individual enzymes, the question arises: How are they assembled and co-ordinated in the cells so that long series of chemical changes are brought about so smoothly? This volume provides an excellent review of recent progress in this second stage of the study of enzyme function.

The notable progress made in recent years in the study of the enzyme activities of isolated mitochondria is the subject of the first two papers. A. L. Lehninger discusses the respiratory activity of rat-liver mitochondria, and D. E. Green the enzymes which are responsible for the citric acid cycle of reactions. The next group of papers deals with the mechanisms of enzyme reactions. E. L. Smith discusses the specificity of proteolytic enzymes—in particular those peptidases which require metal ions such as manganese or cobalt for their activity—and makes the interesting hypothesis that the metal ion is necessary to complete the bridge between the enzyme and the substrate peptide. A. C. Maehly describes the separation of an enzyme, the peroxidase of horseradish, into its component parts and its resynthesis from these parts. B. Chance discusses the reactions of ferrocytochrome-c with peroxidases. In the final paper E. J. Cohn, D. M. Surgenor and M. J. Hunter summarize the results of the very extensive researches on the separation of blood plasma proteins and of liver proteins, which have been carried out during the past ten or twelve years in the Harvard Laboratory. These researches are remarkable for the variety of new technical methods of protein separations which have been devised.

Altogether, this small book provides a very valuable introduction to recent work on complex enzyme systems and, as such, will be widely read.

J. A. V. Butler

BIOLOGY OF HOT SPRINGS

Grundriss zu einer Balneobiologie der Thermen

Von Prof. Vale Vouk. (Lehrbücher und Monographien aus dem Gebiete der exakten Wissenschaften: Reihe der experimentellen Biologie, Band 5.) Pp. 88. (Basel: Verlag Birkhäuser, 1950.) 11.50 Swiss francs.

THIS is a welcome addition to the well-known series of scientific text-books and monographs issued by Verlag Birkhäuser. The physical and chemical properties of natural waters, particularly thermal springs, and also their clinical effects, have received a considerable amount of attention and have formed, separately and in conjunction, the subjects of systematic reviews. While there are on record numerous observations on different forms of life occurring in hot springs and on the species present in different localities, the present monograph is, as far as the reviewer is aware, the first attempt to bring them all together and deal with the specialized ecology of this environment and the various problems associated with it in a systematic manner. It is therefore of considerable interest and may have importance in the practical field.

Thermal waters have been defined as having a more-or-less constant temperature above the average annual temperature of their surroundings; but, as is pointed out, this is not satisfactory from the biological point of view. In arctic or alpine situations this might easily mean that the temperature would be a normal one in lower latitudes or altitudes. Similarly, the differentiation of thermal waters with reference to the temperature of the human body leaves something to be desired. Prof. Vale Vouk proposes a classification based on the types of living organisms present. His grouping is: chliarotherm, 18°–28° C.; eutherm, 28°–44° C.; akrotherm, 44°–65° C.; and hypotherm 65° C. and above. Thus, for example, the only organisms in the last group are Bacteria and Cyanophyceæ, and it is noteworthy that some members of each of these categories can live at temperatures a little above 85° C.; again, no fish or amphibians are known above the eutherm.

Temperature is not the only ecological factor affecting life in thermal waters, for, *inter alia*, there is the question of the nature and concentration of the chemical substances they contain, and these vary with the provenance of the waters. Thus, while the genus *Mastigopus* is cosmopolitan in distribution, it is as a rule confined to akrotherm waters with a limited concentration of mineral salts. These and other peculiarities affecting living organisms, including the 'Fervor effect' of thermal waters, are adequately discussed. The book is well printed and illustrated, furnished with an index and good bibliography, and provides an adequate summary of the present state of our knowledge of the biology of thermal waters.

LEONARDO DA VINCI, ARTIST AND MAN OF SCIENCE (1452–1519)

By Dr. A. TINDELL HOPWOOD
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THE Quincentenary Exhibition in the Diploma Gallery of the Royal Academy throughout the summer is designed to illustrate Leonardo's many interests by means of his own works, particularly his drawings and manuscripts. Emphasis on the drawings was inevitable, for the finest collection of them in the world is that in the Royal Library, Windsor, whereas of the eighteen surviving paintings only one, the "Madonna of the Rocks", is in Great Britain. There is no need to describe the genesis of the Exhibition, or to name the owners (Her Majesty the Queen at their head) who have so generously lent their treasures; this is done in the catalogue, another of those masterpieces of concise scholarship one has come to expect as of right whenever the Academy holds a special exhibition.

The name Leonardo da Vinci is familiar to millions who have never seen any of the original drawings and paintings. For most of them he is the painter of "Mona Lisa" and "The Last Supper", or else a scientist and inventor, born before his time, who made his notes in mirror-writing for fear of the Inquisition. This last point is almost certainly a myth arising from religious prejudices. That Leonardo was left-handed his drawings make plain, and the natural tendency of some left-handed subjects to write from right to left, holding the pencil in the left hand as Vasari and others said that Leonardo did, is sufficient explanation. To others, more widely read, Leonardo means many different things, so universal was his genius; yet, were one to be asked what his achievement was, it would be difficult to give a concise answer. Painter, sculptor and architect; anatomist, rhymester and engineer; herbalist, musician and dandy; he was at once all these and more. None the less, little of his work survives outside note-books and drawings; neither do the accounts of those who knew him, nor those of the following generation, suggest that he ever completed so much as his younger contemporaries Michelangelo (b. 1475) and Raphael (b. 1483).

Why this should have been remains uncertain; but the ceaseless questing of his intellect may well have been the cause. Vasari, who wrote nearly thirty years after the death of Leonardo, suggested that little was finished because so much fell short of the master's aim: he also quoted the remark of Leo X, "This man will never do anything, for he begins to think of the end before the beginning". Another pointer in the same direction occurs in a letter dated April 4, 1504, from Fra Pietro da Novelara to Isabella d'Este, reporting that Leonardo's "mathematical experiments have made painting so distasteful to him that he cannot even bear to take up a brush"; and, in another letter only four days later, "Leonardo's life is changeful and uncertain; it is thought that he lives only for the day. . . . He is entirely wrapped up in geometry and has no patience for painting".

Primarily his fame rested and still rests on his drawings and paintings; his notebooks were not deciphered until long after his death. So far as sculpture is concerned, the great clay horse for the Sforza monument was never cast and was destroyed by the French archers when they entered Milan in 1499: this was his most ambitious piece. For the rest, some small works in marble and terra-cotta from the workshop of Verocchio have been attributed to Leonardo in his young days, as well as two small bronze horses, one in Budapest and one in the present exhibition, and three life-sized bronze figures over the door of the Baptistry in Florence. These last, by Rustici, are supposed to owe much to Leonardo's assistance, although, as Vasari recorded, "nothing definite is known".

While he worked at the model for the Sforza monument, Leonardo studied the anatomy of the horse and compiled a note-book of his observations. The book was lost when the French entered Milan; but some drawings made at that time survived and are now at Windsor. At this same period he also dissected a bear, and on various occasions made drawings of dissections of frogs, birds, monkeys, and even lions. His chief interest, however, was in the anatomy of man, "who ranks among animals as first of the beasts" (in this phrase he anticipated Linnæus by two hundred and fifty years), and the fortunate circumstance that by far the greater number of his anatomical studies is now at Windsor has enabled this aspect of his scientific work to be displayed in remarkable detail. Fully to describe the drawings is not possible; they show that he realized that a horse walks on the tips of its toes, that there are similar structures in the legs of frogs and men, and that he not only described the antrum of Highmore, but also the right and left cardiac atria, the cerebral ventricles, of which he prepared casts in wax, and the valves of the heart. The full extent of these studies, at which he worked for a while with Marcantonio della Torre (1482–1512), professor of anatomy at Padua, is indicated by his statement to Cardinal Luigi d'Aragona in October 1517, only eighteen months before he died, that he had dissected more than thirty bodies of all ages, both male and female.

With so much anatomical work to his credit, one might have thought that Leonardo's time was fully occupied, but it was not; of the more than five thousand pages of notes and sketches still in existence, a large number is concerned with engineering projects, machines and scientific instruments. Some of the sketches illustrate his own inventions, others are the earliest known representation of a given object, and yet others are of machines invented before his day for which he had devised improvements. All these aspects are illustrated in this exhibition, and their interest is greatly enhanced by means of a number of models prepared in the workshops of the Science Museum from his notes and drawings.

Among the models are an *N*-girder bridge, a helicopter designed to have a radius of 14 ft., a parachute, a screw-cutting machine of advanced design, and machines for grinding plane and concave mirrors. These are by no means all. One drawing shows the earliest known observation of magnetic dip, another is of articulated driving chains, which he may have invented, and yet another represents the first known use of a pendulum to regulate a clock.

Lastly, there is a contrivance whereby a "weight jerks violently upward the feet of a sleeper, who is thus awakened and goes about his business". Whether this was seriously meant one cannot say; many similar devices are familiar to students of the history of inventions. The particular interest of Leonardo's apparatus is that it is an early example of a relay mechanism.

Concerning the paintings, it would be difficult to add anything to the notes in the catalogue, particularly as they include selected references to the vast literature that has grown up around the subject; but the smile of Mona Lisa, often called mysterious, is a small point of interest unmentioned in the notes. A like smile, so faint as to be barely perceptible, is to be seen in "La Belle Ferronnière" (Louvre), and again, a little stronger, in the "Lady with an Ermine" (Warsaw, Czartoryski Museum). This smirk annoys some, who point out that the women in religious pictures smile in a normal manner (cf. "The Virgin and Child with St. Anne and St. John": No. 109). It should be borne in mind, however, that Leonardo was the greatest painter of his time, and that his sitters, besides being paintable, were wealthy and fashionable. Now the fashionable smile of the ladies of the Renaissance was that painted by Leonardo; in their books of etiquette it was laid down that they should close the mouth at the right corner and open it on the left as though they were smiling secretly. But the fashionable smile of Mona Lisa was not suitable for sacred art; neither, so far as I am aware, did Leonardo ever depict it there. We have Vasari's authority that while Leonardo was painting Mona Lisa, "he engaged people to play and sing and jesters to keep her merry. . . . This figure . . . had such a pleasant smile that it seemed divine rather than human, and was considered marvellous, an exact copy of Nature". The fame of the smile has not diminished after four centuries and a half; but, "an exact copy of Nature"? How that phrase illuminates the gulf extending between the High Renaissance and the present.

THE BRITISH CONTRIBUTION TO TELEVISION

DURING April 28–May 3, the Institution of Electrical Engineers held a convention on "The British Contribution to Television", which was attended by more than 1,300 registered members, including 137 delegates from twenty-one different countries. The programme comprised ten sessions, at which more than eighty technical papers were presented and discussed, and a number of visits to such places as the B.B.C. television stations and studios, the Post Office Research Station and some dozen firms in the radio industry. A few social gatherings were also arranged, including a Television Ball and Dinner at Grosvenor House, London.

The convention was opened by the Right Hon. Lord Woolton, who surveyed briefly the development of television in Great Britain, starting from the suggestion put forward in 1908 by Mr. A. A. Campbell Swinton to use beams of cathode rays to convert the rapid variations of light and shade into electric impulses at one end, and to reverse the process at the other end of the system. He referred to the facts that the first public television service in the world started in London in 1936; and that the completion of the present plan of installing five high-power and five medium-power stations in Britain will make the television service available to about 88 per cent of the population of the United Kingdom. While we can scarcely expect to emulate the achievements of the United States in their spectacular development of television during the past five years or so, it is gratifying to observe that the radio industry in Britain has taken full advantage of the opportunities provided by the corresponding development here. Many firms must now have, in production, cathode ray tubes and other components assembled in television receivers, on a scale which would have been deemed impracticable a few years ago.

After a brief expression of thanks by Sir John Hacking, president of the Institution, who also welcomed Dr. Donald Sinclair, president of the Institute of Radio Engineers, New York, and other distinguished visitors and guests, an address on "Television Development" was presented by Sir Noel Ashbridge, then the director of technical services of the British Broadcasting Corporation. He traced the growth of the television service in Great Britain from the early experiments of J. L. Baird, with a low-definition system of 30 lines per frame and 12½ frames per sec., to the adoption in 1937 of the system developed by the Marconi-E.M.I. Co., using the technical standards of 405 lines per picture, 25 pictures (50 frames) per sec. with double interlaced scanning and positive modulation. While these standards are practically identical with those in use to-day, there has been much discussion at international committees during the past two years on the relative merits of this and other standards, differing mainly in the use of a greater number of lines per picture. As Sir Noel pointed out, for any improvement to be obtained by the use of more scanning lines, the band-width available at every point in the chain of transmission and reception must be increased correspondingly, with increase in costs all round. If this increased band-width is not available, a worse picture may result than that given by the present system using a smaller number of lines. It is greatly to be regretted that little progress has been made towards internationally agreed standards for television services; and there are, so far, four different specifications for black-and-white television in use, or shortly to be used, for broadcasting.

Looking to the future, Sir Noel said that colour is almost certain to be the most spectacular development in the next few years, and there are two systems sufficiently developed in the United States to merit serious and immediate consideration. No system has, however, been very definitely established on a public-service basis; but it is certain that the costs will be greater than with the black-and-white system in all respects, namely, programme production, technical operation and capital cost. While the use of colour may not be justified in all cases, there is no reason why colour television should not in the end give truer reproduction than colour films have in the past.

Reference was also made to the possibilities of stereoscopic television, with or without colour, and to the other applications of television, such as surgery, whereby a considerable number of people can witness a demonstration under conditions in which limited accommodation would make this impracticable otherwise.

At the second session of the convention, a broad historical review of the development of television was

presented by Messrs. G. R. M. Garratt and A. H. Mumford. The history of television may be said to date from the observations, made by Becquerel in 1839, that when two electrodes are immersed in a suitable electrolyte and illuminated by a beam, an electromotive force is generated between the electrodes. The next stage was the discovery by Willoughby Smith in 1873 of the effect of light on the resistance of selenium. This discovery had no immediate sequel, but the era of stimulated progress which followed Bell's invention of the telephone in 1875 provided the background for numerous ideas for 'seeing by electricity'. Many of the resulting inventions were impracticable, chiefly because other discoveries and developments essential to the realization of the main ideas had not been made. From these beginnings, this paper traced the development of television following the suggestion of Campbell Swinton referred to above, and the introduction of the thermionic valve into radio practice. The presentation of the paper was accompanied by a demonstration of the mechanical system of television reception developed by Baird and used in the early experiments of the B.B.C.

The third session was introduced by Mr. D. C. Birkinshaw with a paper entitled "Television Programme Origination: the Engineering Technique". This paper, which was supported by fourteen others, surveyed the development of the engineering techniques associated with the origination of television programmes in Great Britain. Both studio and outside broadcast equipment were dealt with; much detailed design information from experienced authors is contained in these papers.

At the following session, Mr. P. A. T. Bevan reviewed the television transmitting scheme by which the British Broadcasting Corporation hopes to serve the greater part of the population of the United Kingdom. The basic factors underlying the choice of the scheme are discussed in the paper, together with the arrangements for dividing the available frequency-band into five separate channels. The general design of the complete equipment used at the transmitting stations is described with particular reference to the different types of vision and sound transmitters. The four supporting papers describe some of the special equipment features, including the aerial systems, in greater detail.

A survey of British research on wave propagation with particular reference to television was presented at the fifth session by Dr. R. L. Smith-Rose, and his remarks were amplified in four supporting papers. In this review emphasis was placed on the fact that the planning and successful operation of a national television service involves a somewhat detailed understanding of the mode of propagation of the radio waves concerned. For the service to be successful, a satisfactory ratio of the wanted signal to the prevailing noise or other interfering signals must be established within the reception area of each transmitting station. In addition, in view of the necessity of operating two or more stations in the same frequency-channel, a statistical knowledge of the propagation of the waves concerned to considerable distances is necessary in order to avoid mutual interference of the different transmitting stations. Furthermore, the use of radio links at extremely high frequencies for the exchange of programmes between stations involves a knowledge of the vagaries of the propagation of the very short waves concerned under varying atmospheric conditions. The papers presented at this session contain the results of many years work in this field, and form a basis of fundamental knowledge which has enabled the planning and establishment of a television service to be carried out so successfully in Britain.

With two introductory papers and eighteen supporting contributions, the next session dealt with point-to-point transmission. Dr. A. R. A. Rendall and Mr. W. N. Anderson described the arrangements used for temporary linkages for outside broadcasting purposes; while Mr. H. Faulkner spoke on permanent point-to-point links for relaying television programmes between transmitting stations. The object of these links is to provide a reliable system of transmitting vision signals involving a band-width of 3 Mc./s. over which the electrical characteristics are uniform and stable to a high degree. Experience in Great Britain has shown that excellent results can be obtained either by coaxial cable or by radio transmission, so that the choice between the two systems is largely a question of economics. The present advantage appears to be with the cable links on combined television and telephony routes; but, when radio links have been developed for the simultaneous transmission of television and multi-channel telephony, this advantage will be nullified. An item of interest in this connexion is that the travelling-wave tube, produced in Great Britain during the War, has found its first commercial application in the radio link between Manchester and Edinburgh. At the working frequency of 4,000 Mc./s., its high amplification and low noise-factor render an intermediate-frequency amplifier unnecessary and this reduces the overall cost of the link. The supporting papers describe in detail some of these radio and cable links and the associated equipment and testing apparatus.

The seventh session, on "Industrial Television", was outstanding in so far as the presentation was concerned. By the aid of a television link and a projection-type receiver and large screen, the authors introduced their papers from the lecture hall of the Institution of Civil Engineers, while the audience of more than six hundred watched in the adjacent Great Hall. In his survey paper, Dr. R. G. C. Williams pointed out that Great Britain has pioneered in industrial television no less than for broadcasting. Apart from the use of television for education and training and similar 'large-screen' work, an important application is to take advantage of the 'extension eye' principle in such fields as underwater television, the demonstration of surgical operations and the observation of dangerous processes. Among the eight supporting papers was one by Mr. F. Roberts and Prof. J. Z. Young entitled "The Flying-Spot Microscope". In the presentation of this, the authors demonstrated how the apparatus could give an accurate count of the thousands of minute nerve endings in a human nerve trunk, of which they showed a cross-section larger than had ever been seen before as a result of the magnification of more than half a million times with the large-screen equipment.

The next two sessions of the convention dealt in considerable detail with the problems of television reception, and especially with the design and construction of receivers, and the valves and cathode-ray tubes for use therein. In addition to the two survey papers, there were fifteen supporting papers which had been prepared by experts in the various phases of the reception of television broadcasting.

In the tenth and final session, Mr. L. C. Jesty dealt with "Television as a Communications Problem",

and laid stress on the need for conserving ether space in the transmission of television signals. This phase of the subject will become of enhanced importance when the possibility of colour television is discussed, and also in connexion with the relaying of programmes over very great distances. Ten supporting papers contribute much detailed information to this question, and two of these deal with some fundamental aspects of colour television of both a subjective and objective nature.

There is no doubt that the holding of this convention brought together a large amount of detailed and expert technical knowledge on the various aspects of television described above; and this knowledge will prove very valuable to those responsible for the future development of television everywhere. The complete proceedings of the convention, containing the addresses, the full text of all the papers and reports of the discussions, will be published in four issues (Nos. 17–20 inclusive) of a special volume of the *Proceedings of the Institution of Electrical Engineers*, Part III A. The first of these special issues is expected to appear shortly. Those requiring copies should apply to the Institution of Electrical Engineers, Savoy Place, London, W.C.2, from whom details of the contents and subscription-rates may be obtained.

R. L. Smith-Rose

PRINCIPLES GOVERNING THE AMOUNT OF EXPERIMENTATION IN DEVELOPMENTAL WORK

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GREAT BRITAIN has lagged badly behind the United States in the practical utilization of scientific discoveries. This is reflected in the demand for men of science in the two countries. The recently published Fifth Annual Report of the Advisory Council on Scientific Policy[1], for example, directs attention to the fact that the United States is turning out nearly three times as many men of science in proportion to the labour force as Great Britain is, and is planning further increases, particularly at the higher level. In part this lag in putting scientific discoveries to practical use is attributable to our neglect of the experiments and tests which are necessary in developmental work. These experiments differ markedly from the laboratory experiments required in pure scientific research, since their main function is to establish empirical rules of operation which are applicable under practical conditions. With the present drive for economy there is serious danger that even such facilities as are available for experimental work of this kind will be curtailed or not used to full advantage. It is therefore important to stress that such curtailment will result in much more substantial and immediate losses through failure to determine the best practices. Developmental work must be expanded, not contracted, if we are to survive.

It is perhaps somewhat remarkable that no very precise consideration appears to have been given to the expenditure that is justifiable in developmental work. Instead, experimenters have tended to rely on their intuitive judgment on the accuracy that should be aimed at, and are frequently influenced in this judgment by the demands, often misplaced, for economy. In its essentials the problem is very similar to that of deciding the accuracy required in a sample survey. For this latter problem I put forward the general principle that the accuracy should be such that the sum of the cost of the survey and the expected losses due to errors in the results should be minimized[2]. The same principle can be applied to experimental work. It is indeed here more widely applicable, since it is usually easier in experimental work to assess the losses due to errors of a given magnitude in the results.

In experimental work, however, we have at the outset to consider the type of results that are likely to emerge and the way in which they will be used. In the case of a treatment of the all-or-nothing type we may simply require a decision on whether or not to apply the treatment uniformly to the whole of the material, or to certain categories, already defined, of the material; or we may hope that the experiments themselves will reveal a way of classifying the material into categories for some of which the treatment will be profitable and for others unprofitable. Similarly, in the case of a quantitative treatment, we may require only to determine what uniform level of treatment gives the greatest economic return, or we may hope to divide the material into categories for which different levels of treatment will be most economic, or find some quantitative characteristic of the material which is correlated with the most economic level.

If the discovery of appropriate categories for non-uniform treatment is the aim, more elaborate experiments will often be required. We may also be prepared to sacrifice some of the smaller gains resulting from pushing the simpler type of investigation to its economic limit in the hope of obtaining the much larger gains which will result from the effective use of differential levels of treatment. For the moment, however, we will leave aside these more difficult problems, and consider the simple case in which the whole of the material is to be treated uniformly.

When a decision whether or not to apply a treatment is required application of the above principle is complicated, and we shall not discuss the matter further here. The problem is probably only soluble in terms of fiducial probability, using the sequential approach, and then with difficulty. It is essentially that propounded by Wald in his "Statistical Decision Functions"[3]. When the most economic level has to be determined, on the other hand, the solution is very simple, and reveals a number of features of general interest.

At the outset it will be well to make clear exactly what is meant by the concept of expected loss due to errors in the results. Consider, for example, the question of the use of fertilizer on an agricultural crop. If the whole of the crop is to be treated alike, the most economic level of dressing, which for convenience we will call the *optimum* level, will be the level at which the cost of a further small increment of dressing exactly equals the value of the resultant average increment in response. In the neighbourhood of the optimum the net loss due to departure from the optimum will in general be proportional to the square of the difference of the actual dressing from the optimum. If, therefore, instead of the optimum dressing $\hat{x}$ we apply a dressing $\hat{x} \pm \delta x$ there will be a net loss of $\lambda(\delta x)^2$ per acre, where λ is some constant.

If $\hat{x}$ is estimated by means of a set of experiments, and the estimate is subject to an error variance $V(\hat{x})$, then the average value of $(\delta x)^2$ over a large number of such sets of experiments will be $V(\hat{x})$. The expected loss due to error in the optimum will therefore be $\lambda V(\hat{x})$. The actual loss may of course be less or greater than the expected loss. An inaccurate set of experiments, for example, may by chance give the correct answer.

If, therefore, the cost C, apart from any 'overhead' or constant component, of an amount q of experimentation is cq, and the error variance of the estimate of the optimum level determined from such experimentation is v/q, the expected loss L will be $\lambda Av/q$, where A is the amount of the material to be treated. We therefore have

$$C + L = cq + \lambda Av/q.$$

This is a minimum when

$$q = \sqrt{(\lambda Av/c)}.$$

In this case

$$C = L = \sqrt{(\lambda Avc)}.$$

In other words, *the most economic amount of experimentation is that in which the cost of the experimentation apart from overheads is equal to the expectation of loss due to errors.*

If an amount A of material has to be treated each year for an indefinite period, and the experiments take a year to carry out, A must be replaced by A/r, where $100r$ is the interest rate. If constancy of conditions cannot be assumed indefinitely and it is decided to repeat the experiment after t years, then A is replaced by

$$\frac{A}{r}\left\{1 - \frac{1}{(1+r)^t}\right\}.$$

The net loss resulting from undertaking a fraction or multiple f of the most economic amount of experimentation is

$$(f + 1/f - 2)C.$$

If, for example, the cost, apart from overheads, of the most economic amount of experimentation is £4,000, the costs and losses when f has the values of 1, $\frac{1}{2}$ and $\frac{1}{4}$ will be as follows:

f	Cost of experiments (C)	Expected loss (L)	Cost + loss ($C + L$)
1	£4,000	£4,000	£8,000
$\frac{1}{2}$	£2,000	£8,000	£10,000
$\frac{1}{4}$	£1,000	£16,000	£17,000

This table can be looked on as giving the expected additional gains from additional amounts of experimentation in the neighbourhood of the most economic amount. The total gain from the experimentation as a whole cannot, of course, be assessed by this means. In the common case in which the application of the treatment cannot be risked without *some* experimentation, the total gain will be that due to the use of the treatment. This will often be large compared with the marginal gain in the neighbourhood of the most economic amount of experimentation. If, for example, the gain from using the treatment at the correct optimum level is £100,000, and overheads and preliminary fundamental scientific research are costed at £5,000, with other costs as above, the total and net gains will be as follows:

f	Research expenditure (C + £5,000)	Expected total gain (£100,000 − L)	Expected net gain
1	£9,000	£96,000	£87,000
$\frac{1}{2}$	£7,000	£92,000	£85,000
$\frac{1}{4}$	£6,000	£84,000	£78,000

In other words, the return on the first £6,000 of research expenditure is £84,000, on the next £1,000 is £8,000, and on the next £2,000 is £4,000.

If, therefore, experimental resources are scarce there may be a case for not carrying out the full amount of experimentation that can be justified on economic grounds, since the returns on the last few incremental steps are relatively small, and it may therefore be possible to use the immediately available experimental resources more effectively on other problems. However, the experimentation which is required to determine an optimum for uniform treatment is often capable also, if properly planned, of providing a basis for differential treatment. If successful in this respect further large gains may accrue. Consequently, since gains must on the average result from increasing the experimentation to the most economic level for uniform treatment, even if no effective basis for differential treatment is found, there is every justification for building up an experimental organization which is capable of dealing with this volume of experimentation.

There is one further point which is often of considerable practical importance. In many types of experimentation it is somewhat difficult to ensure that experimental conditions fully conform to the conditions under which the treatment will be used in practice. If this is not the case a constant component of error, that is, a bias, will be introduced. An error of this kind will not be eliminated by increasing the amount of experimentation, nor will it be revealed by the variability of the experimental results. Although the gains resulting from increased experimentation will *on the average* be the same whether or not a bias exists, the elimination of the bias may result in much larger gains. Additional experimental effort may therefore in such cases be much better directed to the elimination, reduction or correction of the bias, rather than to the reduction of the relatively small random component of error. To effect this a radically different type of experiment may be required.

As an example of the application of the above principles to a practical situation we may consider the experimental work on the effect of fertilizers on sugar beet, a crop introduced into Britain after the First World War. The early recommendations were based on Continental experience, but after various unco-ordinated experiments had been carried out a co-ordinated series of factorial experiments was started in 1933 and continued to 1949 to test the responses to nitrogen, phosphate and potash. The average number of experiments was twenty-two per year, and the total annual cost, exclusive of overheads, was about £700 per annum at pre-war prices.

As an example of the practical value of these experiments it may be mentioned that the results obtained up to 1939 enabled confident recommendations to be made in 1940 on the manuring of sugar beet under war-time conditions[4]. It was recommended, for example, that a dressing of 0·7 cwt. nitrogen per acre would be optimal, in contrast to the dressing of 0·45 cwt. nitrogen which had previously been recommended[5], and which was, in fact, about optimum at the prices ruling prior to the War. The net gain resulting from the change from 0·45 cwt. nitrogen to 0·7 cwt. nitrogen was about 15*s*. per acre at 1940 prices. If this change were made on the whole of the sugar beet acreage the total net gain would be £300,000 per annum. The

actual net gain was probably considerably larger, since under-manuring of sugar beet (and other crops) was common before the War.

The determination of the most economic number of experiments in a situation of this type is complicated, owing to the fact that there is an additional random component of variation in response from year to year due to variation in meteorological conditions, and there is also a possibility of long-term changes due to changes in agricultural conditions. Without going into details, which will be dealt with elsewhere, it may be stated that an analysis of the variation in the nitrogen responses indicates that as far as this fertilizer is concerned about sixty experiments per year, possibly falling to forty per year after the first few years, may be regarded as most economic. In view of the fact that many farmers do not as yet follow at all closely the recommendations emerging from such experiments, the programme can be regarded as about adequate for the simple function of determining optimum uniform dressings. Indeed, from this point of view, the most serious defect of the experiments was the fact that the selection of the sites was not fully random, so that appreciable biases may have been introduced into the results.

The experiments were, however, quite correctly undertaken with the additional and more ambitious aim of investigating possible differences in response on different soil types, and establishing relations between responses and chemical analyses of the soils. In the case of nitrogen, for example, it was confirmed that the responses to nitrogen on fen soils (constituting 10 per cent of the sugar beet acreage) were very small, and would not pay for the cost of nitrogenous fertilizer. This fact is still not fully appreciated by the farmers concerned, 85 per cent of whom, according to a 1945 survey of fertilizer practice, applied nitrogen averaging 0·3 cwt. nitrogen per acre. Omission of this nitrogen would save about £25,000 per annum at present prices, that is, about twenty times the annual cost of the experiments. Considerably larger gains may be expected from the better utilization of the differences in response to phosphate and potash on different soil types and their relations with the chemical analyses of soils. That there is room for substantial economies is obvious when it is realized that the total cost of fertilizers [applied to sugar beet is of the order of £3 million per year. For these more ambitious objectives a larger number of experiments would certainly have been economic.

But if the experimental work on sugar beet must be judged to have been scarcely adequate for the purposes for which it was undertaken it is, in fact, the high-light of all experimental work on fertilizers in Great Britain. Sugar beet is the only crop on which any co-ordinated series of modern well-designed factorial experiments has been carried out and the only one for which there has been any attempt to secure a selection of fields for the experimental sites which would be reasonably representative of the whole of the land growing sugar beet. For no other crop is there any adequate series of experiments for which chemical analyses of the soils of the experimental sites have been made, or for which there are any adequate descriptions of these soils. On the more difficult questions of fertilizer practice, such as how to use fertilizers on grassland, and the residual values of phosphate and potash, the amount of co-ordinated experimental work is negligible.

If experimental work in agriculture is to be expanded to a more economic level it will, of course, require a complete reconstruction of the existing machinery for experiments. More work is required not only on fertilizers but also on the many other aspects of crop and livestock production that are capable of simple and exact investigation by empirical experiments. If properly organized, such activities need not interfere with more fundamental scientific research, since technicians rather than research workers are the main requirement. The principal functions of the research workers will be to determine what experiments are worth while, to see that they are properly planned, and to examine the results for relationships which are unknown or only suspected when the experiments are begun.

I have chosen an example from agriculture because this is the field with which I am most familiar, and because it can be demonstrated by the principles set out in this article that the amount of empirical experimentation is here entirely inadequate. The general principles enunciated are of wide application in many other fields, and in particular in many branches of industrial research. The technique of empirical experimentation on highly variable material is relatively new, depending in large part on statistical developments made by British workers during the past thirty years. We have yet to learn how to use this technique to the best advantage, but that it justifies wider and more thorough use there is no question.

[1] Fifth Annual Report of the Advisory Council on Scientific Policy (1951–1952). (H.M.S.O., London, 1952, Cmd. 8561.)
[2] Yates, F., "Sampling Methods for Censuses and Surveys" (London: Griffin, 1949).
[3] Wald, A., "Statistical Decision Functions" (New York: Wiley, 1950).
[4] Crowther, E. M., and Yates, F., "Fertilizer Policy in Wartime: the Fertilizer Requirements of Arable Crops" (*Emp. J. Exp. Agric.*, 9, 77–97, 1941).
[5] Ministry of Agriculture and Fisheries, "Arable Crops on the Farm", Bulletin No. 72, H.M.S.O., London, 1937.

OBITUARIES

Prof. H. A. D. Neville, C.B.E.

Agricultural education and the University of Reading have both suffered a heavy loss by the death on June 17 of Prof. H. A. D. Neville, emeritus professor of agricultural chemistry in the University of Reading.

Neville was born at Blackburn in 1880 and was educated at Queen Elizabeth's School and the Technical College, Blackburn, obtaining, from the latter institution, the degree of B.Sc. (London) as an external student. After a brief spell as demonstrator under Prof. W. J. Pope, at the Manchester College of Technology, he returned to Blackburn as lecturer and demonstrator under Dr. R. H. Pickard. From there he went, in 1906, to the County Laboratories at Chelmsford, and it was here that he made his first contacts with agricultural chemistry. In 1911 he proceeded to Cambridge to work with Prof. T. B. Wood and Prof. F. Gowland Hopkins; there he was in the midst of agricultural chemical teaching and research. August 1914 found him in the Royal Engineers. He rose to the rank of captain and was mentioned in dispatches. By 1917 he was carrying out research in the Munitions Investigation Department. Neville returned to Cambridge early in 1919, but by September of that year he was appointed to the chair of agricultural chemistry at University College, Reading. Within a year he was elected dean

of the Faculty of Agriculture and Horticulture, and continued to hold these positions in the College, and later in the University, until he retired in 1947. In 1948 he was awarded the C.B.E.

In the early days, Neville worked with Pope and Pickard on problems chiefly concerned with the optical activity of a variety of organic compounds. However, his Cambridge days show a complete change of subject, and his researches there dealt with such matters as the fat of yeast and the mucilage of linseed; he was also joint author of a paper on the relative value of white and wholemeal bread. Neville was always described as an excellent analyst and research worker by those who knew him, and in some ways it is to be regretted that the turn of events at Reading led him into administration. Nevertheless, he was the guiding spirit behind the many excellent soil surveys which were carried out by members of his staff between 1925 and 1940.

What was lost to research was gained by the University and the Faculty, for Neville was a first-class administrator. He was one of a small body of men who guided the University College in those important years immediately before the granting of the charter in 1926, and he was the real architect of its Faculty of Agriculture and Horticulture.

The committees connected with university work and particularly with agricultural education on which Neville served are too numerous to mention here; but it was through these that he became known to, and respected by, a large number of people.

H. A. D. Neville was a wise administrator, an excellent teacher and a very good conversationalist; he is gone, but the Faculty of Agriculture and Horticulture of the University of Reading will ever be his monument.

CYRIL TYLER

Dr. F. B. Pidduck

FREDERICK BERNARD PIDDUCK, whose body was found on July 1 on a Lakeland mountainside, had lived at Keswick after his retirement in 1950 from a long and distinguished career in scientific research and teaching at Oxford. Born on July 17, 1885, at Southport, he proceeded from Manchester Grammar School to Exeter College, Oxford, where he gained first-class honours both in mathematics and physics, and also the junior and senior mathematical University scholarships. He then studied for a short time at the Technische Hochschule, Charlottenburg. From 1907 he was a Research Fellow of the Queen's College, Oxford, whence in 1921 he became Fellow and Tutor of Corpus Christi College, where the rest of his official life was spent. During 1916–18 he rendered war service as a research officer in ballistics, with rank of captain, at Woolwich Arsenal, where his work gained official commendation. In 1923 he was awarded the D.Sc.(Oxford) for a thesis that included two important contributions to the kinetic theory of gases. In 1927 he became University reader, having previously been lecturer, in applied mathematics; this position he resigned in 1934. Electrical theory was one of his main interests, and he published two text-books on it, in 1916 and 1937, a technical treatise on currents in aerials and high-frequency networks (1946), and, with R. K. Sas, in 1947, an account of the M.K.S. system of electrical units, for which he was an enthusiast.

He was an extremely able mathematician, who preserved his intellectual originality and vigour to the end of his life. He wrote a series of important papers on the magnetron oscillator, and one of his last papers completes a theory of diffraction which he believed would ultimately take a fundamental place in optics. He was also a skilled experimenter, and long acted as senior demonstrator at the Electrical Laboratory, Oxford.

Active and athletic, Pidduck was an all-the-year-round swimmer, and an amateur photographer. He entered little into the life of his Colleges and University, and was apt to dwell on grievances. His reclusive habit unfortunately deprived his fellow workers of valuable contact with his able and wide-ranging mind, and may have contributed to what with some justification he felt to be an undue lack of public recognition of his notable achievements. One of his characteristics that he took trouble to conceal was his private generosity.

S. C.

Colonel W. C. Devereux

BY the death on June 21 of Colonel W. C. Devereux, science has suffered a loss which is more serious than would normally be the case in the passing of an important and colourful industrial figure. For 'Dev', as he was universally called by his friends—and these included his work-people—combined success in industry with a real appreciation of the value of scientific and industrial research.

This was based not so much on philanthropy as on a knowledge that scientific research was commercially sound and indeed an essential basis for the new and expanding industry of light metals. After the First World War, during which he was superintendent of the first national aircraft factory, he developed the technique of forging light alloy pistons and was in frequent contact with Dr. W. Rosenhain and his team at the National Physical Laboratory in their work on *Y* alloy. The success of the forged piston in practice led to the formation in 1927 of High Duty Alloys, where the research laboratories, which were constantly expanding, were always an essential and integral part of the organization. Constantly in touch with the foundry and factory, the research laboratories none the less produced results of fundamental importance, as instanced by the work of Dr. L. Frommer on stress analysis by X-ray methods and on spectrographic analysis, and the studies of Dr. R. F. Hanstock and his collaborators on damping capacity.

On resigning from the office of chairman and managing director of High Duty Alloys in 1945, Colonel Devereux formed Almin, Ltd., and took the opportunity of founding the Fulmer Research Institute at Stoke Poges. His contacts with research and development in the United States during the Second World War had convinced him of the need in Great Britain for an organization for carrying out sponsored research to supplement the work of private industrial laboratories and co-operative research associations. The growth of that organization, which has more than doubled its staff (which now includes more than thirty graduates) and trebled its income, is an indication of the soundness of his judgment. Although confident of the continued success of the Institute, we cannot over-estimate the loss we have suffered in the dynamic and zestful personality of our late chairman, who quickly became a personal friend to those of us who had the privilege of working for him.

E. A. G. LIDDIARD

NEWS and VIEWS

Chemistry at the Manchester College of Technology: Prof. H. N. Rydon

Dr. H. N. Rydon, who has been appointed to the chair of chemistry at the Manchester College of Technology, succeeds Prof. J. Kenner, who has been made emeritus professor. Dr. Rydon was a student at the Imperial College of Science and Technology, London, where as a Royal Scholar he graduated with first-class honours in 1931. After a period of service on the academic staff at the Imperial College and at Birkbeck College, he was elected in 1937 by the Commissioners for the Exhibition of 1851 to a senior studentship, with which he proceeded to Oxford to continue his researches in organic chemistry. In 1939 he was awarded the Meldola Medal, a distinction reserved for younger chemists of exceptional promise; and in 1941 he was chosen as Harrison Memorial prizeman. In the meantime, Dr. Rydon had accepted a post at the Chemical Defence Experimental Station of the Ministry of Supply at Porton, whence in 1944 he was seconded to the Microbiological Research Department. Later, as a member of the scientific staff of the Medical Research Council Unit for Bacterial Chemistry, he worked at the Lister Institute. In 1947, however, he returned to academic work as reader in organic chemistry at Birkbeck College, University of London; in 1949 he became assistant professor and reader in organic chemistry at the Imperial College, where he has been responsible for the organization and general supervision of the advanced practical exercises in organic chemistry forming part of the new undergraduate course of study. In his earlier contributions to organic chemistry, Dr. Rydon participated in studies on olefinic acids which had been undertaken at the Imperial College by Prof. R. P. Linstead; later, he was associated with Sir Robert Robinson in investigations on the sterols; other researches have been concerned *inter alia* with the chemistry of the 2-chloroalkylamines, with the mechanism of the Michael reaction, with the constitution and synthesis of various organic compounds of natural origin, and especially with the biochemical aspects of bacterial growth and inhibition. Dr. Rydon's major interests at present are the chemical basis of chemotherapy, including the chemistry of peptides, and the organic chemistry of phosphorus.

Thermodynamics in Birmingham: Prof. F. K. Bannister

Prof. F. K. Bannister has been appointed to a newly created chair of thermodynamics in the Department of Mechanical Engineering in the University of Birmingham. The chair has been created in connexion with the organization of the new graduate school in thermodynamics, and Prof. Bannister will be in charge of this school under Prof. G. F. Mucklow, head of the Department of Mechanical Engineering. Prof. Bannister studied electrical engineering at the Burnley Municipal College and took his first degree in physics in the University of Leeds in 1930. He also holds a London external degree in mechanical engineering. He was a lecturer in mechanical engineering at Burnley Municipal College during 1937–40. In 1941 he was appointed lecturer in mechanical engineering in the University of Birmingham, and was granted the degree of Ph.D. in 1946 and became senior lecturer in the Department in the following year. He was appointed reader in thermodynamics in 1951. Prof. Bannister is well known for his work in thermodynamics, and in particular for his studies in the field of the transmission of pressure waves in gases within containing vessels and the application of these theoretical and experimental studies in such problems as arise in internal combustion engines. He was the joint author with Prof. G. F. Mucklow in 1948 of a paper entitled "Wave Action following Sudden Release of Compressed Gas from a Cylinder", which was awarded the Ackroyd Stuart Prize of the Institution of Mechanical Engineers. He has been closely associated with the Air Squadron at the University of Birmingham since its formation in 1941.

Zoology at Birkbeck College, London: Dr. W. S. Bullough

Dr. W. S. Bullough, Cancer Research Fellow and honorary lecturer in zoology in the University of Sheffield, has been appointed to the chair of zoology at Birkbeck College, University of London, as from October 1. Dr. Bullough graduated at the University of Leeds in 1935 and after a period of research joined the staff of that University, becoming lecturer in zoology in 1943. During 1944–46 he was lecturer in zoology at McGill University, Montreal. He then returned to Britain as Sorby Fellow of the Royal Society, a post held with that of honorary lecturer in zoology at the University of Sheffield. He was awarded a Senior Cancer Research Fellowship in 1951. Dr. Bullough has a very large body of published research work to his credit. This has included, in a logical sequence, investigations into the reproductive cycles of fish and the seasonal and hormonal factors influencing them; the reproductive and migratory behaviour in the starling and their possible relation to the incidence of foot and mouth disease; and the mammalian œstrous cycle. From a consideration of the mitotic effects of œstrogenic hormones produced by follicular fluid in the mammalian ovary, Dr. Bullough has more lately directed his attention to energy relations of mitosis. Energy must be stored in sufficient available amount before a cell can divide, and once a division begins it will proceed to the end as an 'all or none' reaction. The hormonal control of these rates of energy production, either by stimulation or inhibition, is now the focus of his attention and may well lead to light being thrown on the evolution of hormonal mechanisms in vertebrates as a whole. Dr. Bullough takes to his new duties a rich experience in three universities both in teaching and research, and Birkbeck College may confidently look to him for a continuation of that activity so well cultivated by Prof. A. Graham, whom he succeeds (see *Nature*, July 5, p. 16).

Heriot-Watt College, Edinburgh: Honorary Fellowships

The Governors of the Heriot-Watt College have conferred the honorary fellowship of the College upon the following, among others: R. Crichton, managing director of Scottish Oils, Ltd., and a governor of the College during 1937–45; G. Mackay, divisional safety engineer, Scottish Division, National Coal Board, and member of the College Mining Consultative Committee; Dr. J. E. Mackenzie, assistant professor of chemistry in the College during 1894–97 and a governor during 1939–51; R. S. Smillie, assistant professor of mechanical engineering in the College during 1919–52; Sir William Wallace,

chairman and managing director of Messrs. Brown Brothers and Co., Ltd., Edinburgh, a former governor of the College and a member of its Advisory Committee on Engineering Studies.

University of Leeds

THE following gifts, among others, have been announced by the University of Leeds: *Department of Colour Chemistry and Dyeing:* The directors of Johnson Bros. (Dyers), Ltd., of Bootle, a dyeing and cleaning company controlling nine works (among them Pullars of Perth, Eastmans of London and Crockatts of Leeds) are providing an endowment fund of £2,000 to provide two studentships each of £50 a year in the Colour Chemistry and Dyeing Department of the University. This gift is intended to commemorate primarily the services rendered by the late Mr. Oswald Gunnell, recently chairman and managing director of the Company, and also in acknowledgment of help received from the University, at which no less than ten of its chemists and managers have been students in the Dyeing Department. *Department of Botany:* £870 over a period of two years from the Rockefeller Foundation towards the cost of a photographic assistant in plant biophysics. *Department of Leather Industries:* Additional equipment to the value of more than £3,000 from the Turner Tanning Machinery Co., Ltd.; equipment to the value of £500 from Messrs. Barrow, Hepburn and Gale; machine valued at £380 from Messrs. Baker Perkins, Ltd., Peterborough.

Prof. D. Thoday, emeritus professor in the University of Wales, has been appointed visiting professor in the Department of Botany during the session 1952–53; the title and status of reader in biomolecular structure has been conferred upon Dr. K. M. Rudall and Dr. J. MacArthur, Research Fellows in the Department of Biomolecular Structure.

A Recent Sunspot

THE largest sunspot for several months came over the sun's east limb on July 9, and for a few days its area exceeded one-thousandth of the sun's hemisphere. This area is not unusual for a spot (spots up to four and even five times this size were observed in 1946, 1947 and 1951), but with the present approach to the minimum of the 11-year sunspot cycle, the appearance of any big spot is noteworthy in itself. A second point of interest was the position of the spot nearly on the sun's equator—1° to 2° south. The circumstances recall the notable equatorial spot of May 1921 which had a mean area for its disk passage of 1,324 millionths of the sun's hemisphere; parts of the spot structure crossed the sun's equator, the mean position being ½° north. This spot was associated with marked disturbance in the earth's geomagnetic field, culminating in a great disturbance lasting from May 13 until May 17—one of the greatest geomagnetic storms ever recorded. However, the recent spot has shown no such parallel of associated geomagnetic or ionospheric disturbance. Only a few minor flares have occurred in Greenwich daylight hours, one of these on July 16 being associated with transient fading on long-distance short-wave radio communication. The joint absence to date (July 19) of intense flares near this sunspot and ionospheric disturbances, both of the solar ultra-violet radiation type and that denoting the effect of solar particles, is significant. By the time this sunspot had reached the central meridian on July 15·1, the area had decreased to about half that when first seen.

Publications in Astronomy from the University of Manchester

THE recent growth of activities in astronomy at the University of Manchester has made it desirable to unify the University publications in this field under the general title of "Astronomical Contributions from the University of Manchester", and three series, numbered as follows, will be published. (1) *Annals.* This series is intended to include publications of observational data or other investigations which, on account of their extent, may be unsuitable for printing in current periodicals. The continuous operation of equipment at the Jodrell Bank Experimental Station for measuring meteor, solar and galactic noise has, in particular, yielded a great amount of observational material, and this will be published at irregular intervals as the occasion warrants. In addition, contributions to theoretical astronomy from the University and its Mathematical Laboratory, which because of their size may not be suitable for publication through other channels, will be incorporated from time to time. The first number, dated April 1952, has recently appeared. (2) *Jodrell Bank Reprints.* Papers on radio astronomy which are communicated to, and published by, the learned societies and other scientific journals in the usual way will be reprinted in this series. At present it includes sixty-eight contributions. Some of the back-numbers are available. (3) *Contributions to Theoretical Astrophysics.* This series, which will likewise consist mainly of reprints from scientific periodicals, was initiated recently and so far consists of three numbers (Nos. 1 and 2 being, however, rather scarce). All three series of publications will be distributed to a wide range of observatories, astronomical institutions and individual scientific workers. Requests for additional copies, or suggestions of additional addresses to which the publications should be sent, will be welcome and will be met as long as the supply lasts. Recipients are asked to reciprocate, on an exchange basis, with publications of their own, two copies being required, one to Prof. A. C. B. Lovell, Jodrell Bank Experimental Station, Holmes Chapel, Crewe, Cheshire, and the other to Prof. Zdeněk Kopal, Physical Laboratories, University, Manchester 13.

Protection of Plants in Europe

BOTH the working parties appointed by the executive committee of the European Plant Protection Organization have now issued their reports (from the Organization at 14 rue Cardinal Mercier, Paris). One party was set up to review the question of the danger to Europe of the introduction of hitherto unreported pests and diseases and to recommend appropriate precautionary measures. The other was asked to examine the quarantine restrictions imposed by governments with regard to certain pests and diseases affecting international trade, and to advise on the general principles on which such restrictions should in future be based. In the first report, twelve pests and diseases are listed affecting, among other crops, fruit trees, roses and potatoes, which would cause serious loss if they became established in Europe. A number of preventive measures such as field inspection, fumigation, post-entry quarantine, seed disinfection and the prohibition of certain packing materials are in general considered adequate to obviate the dangers; but in certain cases an embargo on import might be necessary. Stress is laid on the desirability of limiting permanent govern-

mental restrictions on imports to a minimum, and of utilizing the European Plant Protection Organization as a reporting centre in the event of suspected trouble arising.

The quarantine working party was concerned with four specific plant troubles—Colorado beetle, San José scale, potato root eelworm and potato wart disease. A short account is given of each pest or disease, and the manner by which it spreads. Its control is then discussed in the light of present scientific knowledge so that any legislation imposed may be adequate but not unnecessarily restrictive. For example, distinction is made between the quarantine requirements needed during the active and the hibernating periods of the Colorado beetle. Where fumigation has to be enforced, as in the case of nursery stocks likely to be infected with San José scale, it is suggested that some body such as the European Plant Protection Organization might act as adjudicator on the adequacy of the fumigation arrangements of the exporting country, thereby saving the importer a further fumigation. Other practical recommendations are the discouragement of growing potatoes in nurseries and a plea for the adoption by all countries of a uniform system of soil sampling for eelworm detection. Details of a suitable technique for the latter are given in an appendix. The reports are published in both French and English.

Organization of Nationalized Industries

Nationalized industry forms the theme of a series of research papers published by the Acton Society Trust, and in a recent addition to this series, entitled "Patterns of Organisation" (Nationalized Industry Series No. 9; pp. 32; Claygate: Acton Society Trust, 1951; 2*s*.), is found a description of the structure of the various nationalized boards together with a critical appraisal of the assumptions underlying their structure. The idea that large organizations are more efficient than small took firm root in the thinking of the inter-war years. Technicians and engineers were absorbed by the idea of being able to plan for bigger units; the trade-union movement was dominated by the idea of relying upon national agreements to prevent inequitable treatment in any single area; and when the Second World War came, administrators learned successfully how to operate nation-wide controls. The present patterns of organization have been determined by the co-incidence in time of these trends; and the Acton Society Trust pamphlet points out that it has been too readily assumed that the limiting factor is the capacity of management to manage, to the neglect of much evidence that the limiting factor resides in the capacity and needs of the workman. The human factors—desire for status, resistance to change, fear of the future—impede the introduction of changes which the new regime was intended to bring about. Basic units in each industry should be small enough to preserve loyalties and personal contacts between managements and employees and between the industry and the public. It is also argued that the co-ordination of these units can be achieved by some much looser system of organization than that at present operating.

Shirley Institute: Report for 1950

The "Shirley Institute Year Book, 1951" (pp. 125; Manchester: British Cotton Industry Research Association, 1951) includes, besides the annual report for 1950, concise accounts of its present organization and services to members with plans of the proposed extensions and the existing offices, laboratories and workrooms, and a chronology of the Institute's historical background and growth. The annual report includes an account of the ceremony on June 14, 1950, of the laying of a foundation stone for the new building scheme, with reports of the speeches made then and at the annual general meeting of the Association on November 9, 1950. Tributes are paid in the report to the services of Dr. J. C. Withers, who retired at the end of September 1950 after thirty years of service as head of the Information Bureau, chief librarian and editor of the "Summary of Current Literature", and to L. H. C. Tippett, head of the Mechanical Processing Division, who was awarded the Warner Medal of the Textile Institute on June 8. The major change in internal administration during the year was the appointment of J. H. Black as head of a new Information Department to co-ordinate all the information services of the Institute, including the library, abstracting, technical inquiries and publications, and the illustration office. Among research results stress is laid on the successful industrial application of the Shirley accelerated drying device and the introduction of the Shirley automatic size box, a revolutionary method of regulating the percentage of size added to the warp before weaving. The Shirley electrostatic eliminator, designed for the rapid removal of static electricity in high-speed processes, seems likely to be of value in other industries. Besides a list of members on January 1, 1951, appendixes to the report give details of the Council, committees of Council, publications of the Institute in 1950, and periodicals taken by and books added to the Library.

Italian Society of Geophysics and Meteorology

The Italian Meteorological Society, founded in 1881, unfortunately had to discontinue its activities during the Second World War. Prof. M. Bossolasco, Geophysical Institute, University of Genoa, who has been very active of recent years in the organization of international geophysical symposia in Italy, now writes, as secretary, to announce the foundation during May of the Italian Society of Geophysics and Meteorology. The Society's interests are planned to cover a very wide scope: they will include meteorology with climatology and bio-climatology, terrestrial magnetism, atmospheric and telluric electricity and radioactivity, seismology, volcanology, oceanography, hydrology, geodesy and geophysical prospecting and their applications. It is planned to begin publication of a Bulletin in the autumn. Membership, which is stated to be already some 120, is open to foreigners as well as Italians, and applications are invited; the annual subscription, which covers supply of the Society's publications, is only 500 lire. British geophysicists and meteorologists will wish the new Society every success.

Plastics Industry Education Fund

The trustees of the Plastics Industry Education Fund, the chairman of which is Mr. P. C. Allen, have recently announced that the total sum they have made available or authorized for expenditure during 1952 is £4,700. Some of the details of this money are as follows. £1,000 is to be made available during the year for the award of ten training grants for students and £100 for travelling and educational expenses for apprentices attending recognized technical colleges.

It has been decided to revise and re-print four of the series of technical monographs originally published by the Plastics Institute, and £1,000 has been allocated for this purpose. £200 has been allocated for the purchase of text-books for the libraries of the local sections of the Institute, with a further special donation of £200 to establish a library for the newly formed South Wales and Monmouth Section. It has been agreed to allot £1,250 for the purchase of capital equipment for technical colleges during 1952, and the trustees have asked the Plastics Institute to make specific recommendations concerning the equipment to be purchased and the colleges to benefit.

International Congress of Psychology

THE International Congress of Psychology will hold its next meeting, in 1954, in Montreal, instead of in New York as previously planned. The American Psychological Association and the Canadian Psychological Association will be joint hosts for the meeting. In making this announcement, the American Psychological Association gives as the main reason "the delays and embarrassments which foreign scientists experience in attempting to obtain even temporary admission to this country". The Internal Security (McCarran) Law is considered to be responsible, and, by its restrictive action, to be damaging the exchange of ideas between the United States and the rest of the world. Some two thousand psychologists are expected to attend the congress in Montreal.

Instruments and Measurements: Conference in Stockholm

THE Royal Swedish Academy of Engineering Sciences (I.V.A.) and the Association of Technical Physicists (T.F.F.) are arranging an "Instruments and Measurements Conference 1952" to be held in Stockholm during September 22–25. The Conference will be organized into the following main groups: methods of measurement in physical chemistry; methods of measurement and control in industry; mechanical methods of measurement and metrology; methods of measurement in nuclear physics and radioactivity; and miscellaneous methods of measurement. Symposia will be arranged in the first four groups. The official languages of the Conference will be English, German and French. A preliminary programme, with a list of papers, is now ready. All communications regarding the Conference should be addressed to Yngve Axner, Kungl. Tekniska Högskolan, Stockholm 70. An exhibition of instruments and laboratory equipment will be held in the Exhibition Halls of the St. Eriks Fair during September 23–30, to which members of the Conference will be admitted free of charge. Further information on the exhibition can be obtained from St. Eriks-Mässan, Lidingövägen 10, Stockholm 26.

The Night Sky in August

FULL moon occurs on Aug. 5d. 19h. 40m., U.T., and new moon on Aug. 20d. 15h. 20m. The following conjunctions with the moon take place: Aug. 4d. 18h., Mercury 6·4° S.; Aug. 12d. 17h., Jupiter 7° S.; Aug. 19d. 12h., Mercury 4° S.; Aug. 22d. 06h., Venus 4° N.; Aug. 24d. 15h., Saturn 7° N.; Aug. 28d. 05h., Mars 3° N. Mercury is in inferior conjunction on Aug. 12 and cannot be observed during the first part of the month; towards the end of the month it is a morning star, rising at 3h. 30m. on Aug. 31, when its stellar magnitude is 0. Venus, an evening star, rises at 20h. 15m., 19h. 55m., and 19h. 25m. at the beginning, middle and end of the month, respectively, stellar magnitude − 3·3. Mars is an evening star, setting at 22h. 30m., 21h. 55m. and 21h. 15m. on August 1, 15 and 31, respectively, its stellar magnitude varying from 0 to 0·3 during this period. It is close to α Libræ early in the month and moves eastward until it is a little south of β Scorpii at the end of the month. Jupiter rises at 23h., 22h. 10m. and 21h. 10m. on Aug. 1, 15 and 31, respectively, stellar magnitude about − 2. The planet is nearly 3° south of δ Arietis during most of August. Saturn is an evening star, setting at 21h. 50m., 21h., 19h. 55m. at the beginning, middle and end of the month, respectively, stellar magnitude 1·1. It moves from a position close to γ Virginis to north of θ Virginis during August. The Perseid meteors will be active during the month, the maximum of the shower occurring about August 10–12.

There will be a partial eclipse of the moon on Aug. 5, partly visible at Greenwich. The circumstances of the eclipse are as follows:

Moon enters penumbra	Aug. 5d.	17h.	26·6m.
Moon enters umbra	5	18	33·4
Middle of the eclipse	5	19	47·4
Moon leaves umbra	5	21	01·4
Moon leaves penumbra	5	22	08·2

The magnitude of eclipse is 0·538, the moon's diameter being 1·0. An annular eclipse of the sun on August 20 is invisible at Greenwich. It will be visible over portions of South America.

Announcements

THE following appointments have been announced by the University of Sheffield: F. T. Williams, lecturer in the Postgraduate School of Mining; B. R. Pursall, lecturer in the Department of Mining; P. H. Price (at present research assistant to the professor of fuel technology) to be lecturer in fuel technology; R. G. Siddall, research assistant to the professor of fuel technology; E. H. Gillespie, honorary lecturer in bacteriology. Dr. B. Donovan, lecturer in physics, has resigned on appointment as senior lecturer in physics at the Northern Polytechnic, London.

THE Research Fund of the Chemical Society provides grants for the assistance of research in all branches of chemistry. About £700 per annum is available for this purpose, the income being derived from a donation of the Worshipful Company of Goldsmiths, from the Perkin Memorial Fund, and from other sources. Applications for grants should be submitted to the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1, on the appropriate form not later than November 15, 1952.

THE American Embassy and the United States Educational Commission in the United Kingdom announce a programme of grants to assist senior British scholars to lecture or carry out research in the universities of the United States. The grants will be paid in dollars, and they will be tenable for the academic year 1953–54; the monthly stipend will not be more than 270 dollars. Applicants must be citizens of the United Kingdom or Colonies, and should have a plan for research which can be effectively carried out in the time they propose to spend in the United States; they must arrange their own affiliation with a university in the United States. Application forms, to be returned before November 15, can be obtained from the Assistant Cultural Relations Officer, Room 302, 41 Grosvenor Square, London, W.1.

ORIGIN OF THE DEFORMATION TEXTURES OF TITANIUM

By D. N. WILLIAMS and Prof. D. S. EPPELSHEIMER
Missouri School of Mines and Metallurgy, Rolla, Missouri

BY proper choice of assumptions, it has been possible to develop a satisfactory theoretical explanation of the tension, compression, and cold-rolled textures of titanium using the graphical method of texture analysis recently reported by Calnan and Clews[1].

The observed textures of titanium can be summarized briefly as follows: *tension*, strong $[10\bar{1}0]$[2]; *compression*, [0001] rotated 30° from the compression axis at low reduction. Angle of rotation decreases with increased reduction. Some evidence indicates that $<10\bar{1}0>$ is the preferred axis of rotation[3]; *cold rolled*, (0001) $[10\bar{1}0]$ rotated 30° or more toward the transverse direction[4]. It is apparent from these results that some mode of deformation previously unreported in hexagonal metals is occurring in titanium.

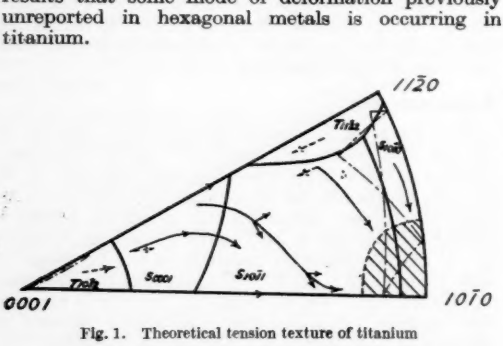

Fig. 1. Theoretical tension texture of titanium

Rosi, Dube and Alexander[5] report that at low reductions titanium exhibits $\{1010\}<11\bar{2}0>$ and $\{10\bar{1}1\}<11\bar{2}0>$ slip, and $\{11\bar{2}2\}$, $\{11\bar{2}1\}$ and $\{10\bar{1}2\}$ twinning. Although they found no evidence of $\{0001\}<11\bar{2}0>$ slip, examination of the deformation textures shows that it must be present, at least at higher reductions.

These modes of deformation were examined separately and then combined to give the observed deformation textures. A satisfactory theoretical texture was developed when the critical shear stresses for slip (C_s) and twinning (C_t) were related as follows: $C_s(0001) = 1{\cdot}1\,C_s(10\bar{1}1) = 1{\cdot}02\,C_s(10\bar{1}0) = C_t(11\bar{2}2) = C_t(10\bar{1}2)$. Since $\{11\bar{2}2\}$ and $\{11\bar{2}1\}$ twinning have the same general effect, only $\{11\bar{2}2\}$ twinning was considered.

The areas within the unit stereographic triangle in which each of the above modes of deformation is favoured are shown in Figs. 1 and 2 for tension and compression respectively. Twinning reorientations are shown by dashed arrows, and slip rotation tendencies by full arrows. The final texture resulting is shown by the shaded areas.

The cold-rolled texture may be approximated by assuming tension in the rolling direction and compression along the rolling plane normal. In Fig. 3 the 0001 pole figure which would result is shown.

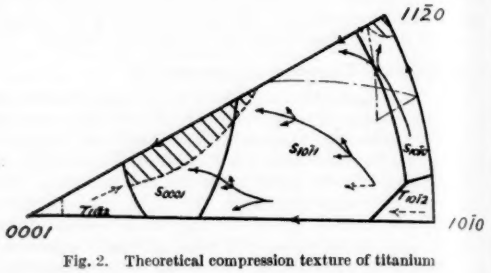

Fig. 2. Theoretical compression texture of titanium

Tension in the rolling direction causes those 0001 poles within 29° of the rolling direction to twin on the $\{10\bar{1}2\}$ planes to a region near the transverse direction. $\{11\bar{2}2\}$ twinning in compression removes 0001 poles within 30° of the rolling plane normal to a new position along the circumference of the pole figure. Twinning reorientations are shown by dashed arrows.

Slip can be assumed to result from combination of compression and tension tendencies. Compression rotates the 0001 poles toward the normal to the rolling plane. Tension rotates the $10\bar{1}0$ poles into the rolling direction and thus rotates the 0001 poles toward the transverse axis. The tension and compression rotations are shown by arrows marked *T* and *C* in Fig. 3. The resultant rotation is marked *R*.

As the amount of cold-rolled reduction increases, a point is soon reached beyond which the principal movement is slip rotation by compression toward the normal to the rolling plane along the transverse axis, followed by twinning at an angle of 30° from the

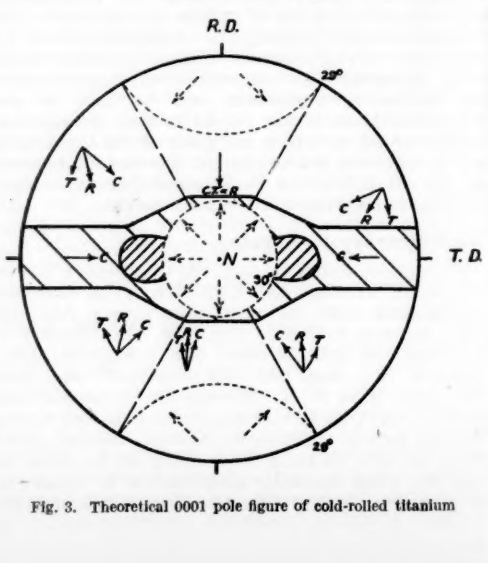

Fig. 3. Theoretical 0001 pole figure of cold-rolled titanium

normal to the rolling plane back toward the transverse direction. The slip rotations and twinning reorientations will occur by rotation about a fixed set of $10\bar{1}0$ poles in the rolling direction. The resulting 0001 pole figure is shown by shading in Fig. 3.

Complete details of the analysis of the various modes of slip and twinning, along with experimentally determined textures using Geiger-counter techniques, will be published elsewhere.

The work described above was carried out under a research fellowship supported by the Titanium Alloy Manufacturing Division of the National Lead Company. [March 4.

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A NEW APPROACH TO THE PROBLEMS OF THE SPREAD OF APHIDS AND TO INSECT TRAPPING

By Dr. C. G. JOHNSON
Rothamsted Experimental Station, Harpenden

IN recent work with *Aphis fabæ*[1], trapped while flying from infested bean crops, the usual statistical procedures failed to distinguish fluctuations in numbers due to flight behaviour from those due to population changes. This makes it necessary to reconsider current views on the spread of aphids as well as the analysis of trap data in entomological research.

Current Views and Recent Work on Aphid Migration

Resting winged aphids when exposed to winds greater than 1·5–2·0 m.p.h. will not take flight[2–5]. It has therefore been inferred that relatively little migration occurs in windy weather[2,4,6], although shelter may allow some to take place from within crops[6–8]. This idea seemed to be supported by the results of trapping in the field[9,10] and also by the fact that high aerial concentrations are commonly *seen* only in calm weather and because only then are single plants colonized[11]. Moreover, take-off, colonization and numbers in the air have all been considered in relation to the weather of the occasion, so tacitly over-emphasizing the role of flight behaviour in migration changes. Observations on the actual numbers of aphids in the air over continuous, consecutive, short periods, adequately associated with meteorological data, have hitherto been lacking. Such observations have now been made with suction traps[1,12], and so far from indicating that most migration occurs in calm weather, the opposite appears to be the case.

Correlations between wind-speed and the numbers of *A. fabæ* and other species[1,12] in the air, though sometimes statistically significant, are not strong. Rapid periodic changes in the number of winged aphids on the crop mask the effect of weather-induced changes in the percentage which fly. This factor, hitherto insufficiently appreciated, is partly due to accumulation of alatæ in the interval between moulting and flying, and partly to their depletion on the crop by flight. A 100 per cent take-off from 100 aphids on one day produces a smaller flight than a 50 per cent take-up from 300 on the next; and successive increases in percentage which fly could be accompanied by successively smaller catches as the population diminishes. In fact, it is impracticable to assess degrees of take-off from aerial numbers alone, or vice versa. Even where aerial numbers and wind-speed were negatively correlated, the scatter showed that considerable flights occurred in windy as well as in calm weather. Moreover, mass migration is possible without any local accumulation in the air at low levels; for example, 995 *A. fabæ* were caught in 20,000 cu. ft. at crop-level (a very high density) on July 6, 1949, but the aphids flew upwards from a sheltered situation into a windy one.

Other evidence that has come from our continuous trapping is that only 23 per cent of all the *A. fabæ* trapped over the whole migration period of five to six weeks (and 25 per cent of all other aphid species) were caught during hours when the mean wind-speed was less than 3 m.p.h. Since the trap measures aerial density, catch × wind-speed × hours indicates the number of insects passing a vertical front of constant area at trap-level: by this calculation only 7 per cent of all the *A. fabæ* (and of other aphid species 9 per cent) passed at mean wind-speeds less than 3 m.p.h. Thus nearly all the aphids flying were being dispersed during relatively high wind velocities with little or no voluntary control of direction.

This result is largely due to the few calm hours which occur in south-eastern England during the periods of the day when aphids fly; in July 1949 only 19 per cent had mean wind-speeds less than 3 m.p.h.

Analysis of Trap Data in Entomology

The number of insects in the air is a compound effect of population-level and degree of flight 'activity'. The separation of these two factors in trap data has usually been attempted by statistical procedures, on the assumption that relatively long-term changes are largely due to population fluctuations, short-term ones depending more on activity[13,14]. Thus fluctuations in the running means of catches are assumed to reflect chiefly population change, short-term deviations from the running mean chiefly flight activity. Similarly, differences between the logarithms of catch for successive days or nights have been taken to indicate activity; and differences between two days at wider intervals to reflect population change[14]. This method may work with relatively stable populations when insects return to the locality after flight or, if they migrate, they are replaced by an equivalent number from elsewhere. But the method fails with aphids[1], and no doubt with other insects where rapid, large population changes contribute more to changing numbers than do variations in flight behaviour. It appears, therefore, that this method of analysis cannot be used indiscriminately without regard for the biology of the insects concerned; for deviations from a running mean or differences between the logarithms of successive catches will reflect either population, immigration or other behaviour changes, according to which has the greater effect on aerial numbers. Thus Muller and Unger's results[4,5] for *A. fabæ* obtained by the use of deviation analyses must be treated with reserve, for they may reflect moulting-rate more than flight activity.

I have found that the greatest numbers of aphids migrated in windy weather; therefore, a lack of colonization may be due, not to absence of migration, as previously thought, but to unsuitable conditions for alighting. The significant epidemiological factors may not be take-off changes so much as population-levels, alighting behaviour, and the kinds of crops and situations which affect it.

Alighting requires calmness: therefore, single plants[11] or crops affording little shelter may possibly be colonized only in the relatively infrequent calm periods. This type of aphid distribution might be associated more with short flights favouring the transmission of viruses with a short life in the aphid. On the other hand, crops providing plenty of shelter among stems, or on the lee side, may be colonized continuously by longer-range flights of wind-borne aphids, and this type of dispersal may be associated more with persistent viruses.

Traps are of undoubted value in measuring aerial populations. But it must be emphasized that they are not always suitable instruments, when used by themselves, for the analysis of population and activity factors. [April 18.

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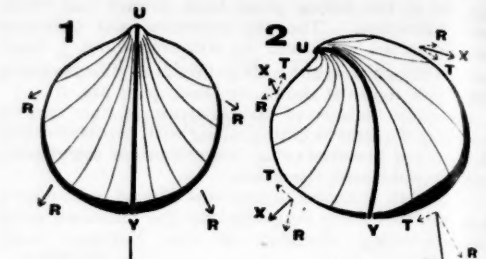
SHELL-FORM IN THE LAMELLIBRANCHIA

By G. OWEN

Zoology Department, University of Glasgow

IN the Lamellibranchia, marginal increase of the shell valves results from the activity of the mantle edge which is thus responsible for the form of the shell. The direction of growth at any region of the mantle edge may be conveniently resolved into a number of components. In the primitive bivalve, the form of both valves was probably the resultant of: (*a*) a radial component radiating from the cardinal region of the hinge and acting in the plane of the generating curve (represented by the valve margin); (*b*) a transverse component acting at right angles to the plane of the generating curve. Certainly the form of the shell valves in many modern lamellibranchs, for example, *Glycymeris* (Fig. 1) and *Tellina*, is the resultant of radial (*R*) and transverse components (Fig. 3, *P*). In some genera, for example, *Pecten* and *Gryphæa*, growth of only one of the valves is the resultant of these two components; growth of the other, flat valve is the result of the radial component only.

The magnitudes of the radial and transverse components increase from either end of the ligament around the margins of the mantle and shell edge



Figs. 1, *Glycymeris*; 2, *Venus* type bivalve; 3 and 4, the right valves of 1 and 2 viewed from the umbonal region, that is, dorsally; 5, *Ensis*.

AU, directive plane; *P*, transverse component; *R*, radial component; *T*, tangential component; *U*, umbo; *UY*, normal axis; *Y*, normal zone; *X*, the direction of growth in Fig. 2. In Figs. 1, 2 and 5 the transverse component acting perpendicular to the plane of the page is not shown. The thickened regions at the valve margins indicate greatest marginal increment

(Fig. 1). Thus, there is a region of the mantle edge ventrally where the effect of the transverse component is greatest (*Y*). In those lamellibranchs in which the generating curve is in one plane (that is, unlike members of the Myidæ and Pholadidæ), it is proposed to describe this region as the 'normal zone' of the mantle edge. Since the effect of the transverse component is greatest at this region, the normal zone secretes that sector of the shell which exhibits the greatest concavity and in this sense is the *Gewoblescheitelbahn* defined by Haas[1]. It is proposed to designate a line (*UY*) drawn along the centre of this sector of the shell as the 'normal axis' of the lamellibranch mantle and shell. The normal axis can thus be considered with reference to three points: the umbo, the normal zone of the mantle edge and the point at which the greatest transverse diameter of the shell intersects the surface of the valves.

In those bivalves in which the form of the shell valves is the resultant of these radial and transverse components alone, for example, *Glycymeris* (Fig. 1), *Tellina*, *Anodonta* and *Ensis* (Fig. 5), the normal axis (*UY*) is in one plane; that is, it is a plano-spiral. Each of the valves would, if a complete whorl were produced, describe a plano-spiral about the umbo. Enlargement of the generating curve with growth results in the growth curves anterior and posterior to the normal axis being increasingly displaced from the normal plane, so that, unlike the normal axis (*UY*, Figs. 1 and 5), they are turbinate spirals. The form of the shell valves in many lamellibranchs, however, is affected by an additional component acting tangentially to, and in the plane of, the generating curve (Fig. 2, *T*). In genera such as *Cardium*, *Venus* or *Mytilus*, as a result of this tangential component, the normal axis (*UY*) is no

longer a plano-spiral but a turbinate spiral. In this case, each valve would, if a complete whorl were produced, describe a turbinate spiral about the umbo.

Growth of the shell valves in *Glycymeris* (Fig. 1) is not affected by a tangential component. The normal zone (*Y*) is mid-ventral and coincides with the region of greatest marginal increment. Moreover, both marginal increase and the effect of the transverse component decrease symmetrically around both sides of the mantle and shell edge. Each valve is therefore symmetrical about the normal axis. The normal zone, however, need not coincide with the region of greatest marginal increase. Thus, in *Gari tellinella*, the generating curve is an ellipse which is roughly symmetrical about the normal axis. There are two regions of maximum marginal increase symmetrically disposed at either end of the ventral margin. The effect of the transverse component remains, however, greatest mid-ventrally. But in genera such as *Anodonta* or *Ensis* (Fig. 5), the generating curve is asymmetrical about the normal axis (*UY*). Maximum marginal increase takes place posteriorly while the normal zone (*Y*) remains ventral to the umbo. The normal axis is in one plane and, as in the symmetrical shells of *Glycymeris* and *Gari*, each valve would, if a complete whorl were produced, describe a plano-spiral about the umbo.

The form of the shell should, therefore, be considered with reference to: (*a*) the form of the spiral (namely, plano- or turbinate) of the normal axis; (*b*) the spiral angle of the normal axis (giving a measure of the concavity of each valve); (*c*) the outline of the generating curve.

Lison[2] claims that the form of the lamellibranch shell is dependent on: (*a*) the angle of the directive spiral; (*b*) the angle of incidence, that is, the angle between the directive plane and the plane of the generating curve; (*c*) the outline of the generating curve. Much depends on Lison's concept of the 'directive plane' of the lamellibranch shell. This is defined by him as follows: "Chez les lamellibranchs existe toujours un plan et un seul, dans lequel s'inscrivent sur toute leur longueur une ou des côtes représentant des courbes planes. Ce plan, qui passe nécessairement par l'umbo, sera appelé le plan directeur de la coquille". According to Lison, this directive plane may be perpendicular to the plane of the generating curve (for example, *Pecten*), or it may be, as in the majority of lamellibranchs, more or less inclined to the plane of the generating curve.

In those genera (*Glycymeris*, *Gari*, *Anodonta* and *Ensis*) in which the 'angle of incidence' is 90° (Fig. 3, *AUB*), the plane of what is here described as the normal axis (*UY*) is identical with this directive plane (*AU*). These, however, are all lamellibranchs in which there is *no tangential component* affecting the form of the shell. In *Corbis fimbriata*, quoted by Lison as possessing the directive plane inclined to the plane of the generating curve, there is a small tangential component (Fig. 2, *T*). As shown in Fig. 4, the normal axis (*UY*) is no longer in one plane, and the turbinate spiral ribs posterior to the normal axis are 'deflected' anteriorly as a result of the tangential component. It follows that one of these ribs will come to lie effectively in one plane (Fig. 4, *AU*). As shown in the diagrams, change in the position of the directive plane is a result of the tangential component and will be related to the magnitude of this component. Moreover, in members of the Chamidæ and Glossidæ (that is, *Isocardia*) the magnitude of the tangential component is such that *all* growth curves of the mantle and shell are turbinate spirals; there cannot, therefore, be any directive plane as defined by Lison.

It is hoped to discuss elsewhere the effect of the tangential component on the ligament and hinge teeth. It should be noted, however, that in the majority of lamellibranchs in which the form of the mantle and shell is affected by a tangential component the anterior region of the ligament is progressively split as growth proceeds. [April 21.

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MOLYBDENUM IN RELATION TO CROPPING AND LIVESTOCK PROBLEMS UNDER IRISH CONDITIONS

By Dr. T. WALSH and M. NEENAN
(Soil Laboratory)

and Dr. L. B. O'MOORE
(Veterinary Research Laboratory)

Department of Agriculture, Ireland

IT has been shown[1-3] that molybdenum, although an essential element in plant nutrition, can, when present even in moderate excess in herbage, cause nutritional disorders in livestock. Investigations which we have on hand on the importance of this element under Irish conditions have indicated that it may be of considerable importance from both the deficiency and toxic aspects. Some of the more important findings of this research are recorded here.

Deficiency aspects. When a sandy loam soil of *p*H 5·3 and low calcium status was used in a pot experiment with *Trifolium subterraneum* as an indicator crop, a striking response was obtained from the application of a small quantity of molybdenum, this response being specially evident in the presence of mono-calcic phosphate. A field experiment with swedes on a soil of similar type also showed a response to applications of molybdenum. This soil also gave a highly significant response to the application of lime, and results now available from the analysis of soil and herbage point to this response as being due in part at least to an increase in the availability of molybdenum in the soil following liming.

When investigating a case of infertility in an organic soil (loss on ignition 95 per cent, *p*H 5·5, available calcium 2,500 p.p.m. and moderately well supplied with major elements), it was found in pot experiments using *S*.100 white clover as an indicator crop that, while the application of a full supplement of nitrogen, phosphate and potassium caused little if any improvement in growth, a striking response was obtained when molybdenum was added to this dressing. A similar response was obtained from the full supplement plus chalk while, on the other hand, the addition of copper sulphate to the full supplement caused a definite depression in growth. Analysis of the herbage showed that the plants receiving the nitrogen–phosphate–potassium supplement contained 2·5 p.p.m. of molybdenum. Those receiving chalk in addition contained a similar level, whereas those

receiving copper sulphate contained less than 0·5 p.p.m. of molybdenum. Plants receiving nitrogen–phosphate–potassium plus molybdenum (5 p.p.m. of soil) contained 24 p.p.m., rising to 38 p.p.m. where 20 p.p.m. of molybdenum was applied to the soil. This instance of molybdenum deficiency in organic soil appears to be unusual, as hitherto such conditions have been usually associated with toxicity of this element[2].

Excess. Instances of a syndrome occurring in cattle associated with unthriftiness, stunted growth in young animals and rough, staring, depigmented coats have been investigated in a number of areas. The coats of red-coloured animals sometimes assume a faded yellow appearance, while although scouring is not a constant feature it has been observed in a few cases. Symptoms are generally similar to those described by other workers[2,4] as being due to a conditioned copper deficiency. Copper dosage is specific as a control. While analysis of herbage samples where affected cattle are depastured have shown normal copper values, that is, greater than 7 p.p.m. (dry matter), the molybdenum content ranged from 5 to 20 p.p.m. On the basis of data quoted elsewhere[2] in connexion with a similar condition in livestock, the above figures are well within the range which represents a moderate excess, the accepted normal for herbage being in the range 1–3 p.p.m. We have also verified the latter figures for normal pasture. It seems reasonable to conclude that the level of molybdenum reported is at least partly responsible for the occurrence of this condition in livestock. While in some of the animals examined the blood copper values tended to be low, that is, of the order of 0·3 mgm./litre, this was by no means a constant finding. Hæmoglobin-levels were normal, and hæmatological studies presented no evidence of anæmia. In view of other findings[5] where an association has been established between defects in bone building in cattle showing symptoms of copper-deficiency and the effects of molybdenum on the utilization of copper and indirectly of phosphorus, it is of considerable interest that we have found the condition reported to be invariably associated with herbage of high calcium content and often of wide calcium to phosphorus ratios, while in several instances blood determinations have shown that deficiencies of both copper and phosphorus co-existed in the same animal.

While this condition occurs frequently on organic soils very similar to those described[2] as being associated with 'peat scours' and other nutritional troubles in livestock, in our investigations it has in addition been found to occur on what are otherwise fertile loams of limestone derivation and typical of important and widely distributed soil series. It may be of further interest that, where the worst excesses have been reported on these mineral soils, the phosphate-level of the latter has been satisfactory. This corresponds with the experience elsewhere[6], as phosphate has been shown to increase molybdenum uptake and also agrees with our pot-culture findings reported above. In two instances also, basic slag used as a fertilizer accentuated the trouble, this being attributable not only to the phosphorus effect but also to the fact that basic slag contains appreciable quantities of molybdenum.

The total molybdenum content of the soils examined, with one exception so far, and representing both the deficiency and excess conditions, was normal, with a range of 0·42–3·50 p.p.m. In one soil a level of 20 p.p.m. has been found. It was found that where response to molybdenum was obtained, the values were less than 0·12 p.p.m. available molybdenum, the latter being determined by the oxalate method, whereas in the soils where the herbage contained excess quantities the soil values were very considerably higher, varying from 0·30 to 0·57 p.p.m. of available molybdenum. Where deficiencies have been identified, the *p*H of the soils varied from 4·9 to 5·5; that in soils associated with this nutritional disorder and excess molybdenum in the herbage have ranged from *p*H 6·5 to 7·8. This corresponds with other observations[7,8] which show that the availability of molybdenum is greatest within the latter *p*H range. It may be of further interest also that, when a fertile soil which contained a total of 0·86 p.p.m. of molybdenum and had a *p*H of 7·8 was used in a pot experiment with *T. subterraneum*, the latter contained 14 p.p.m. of molybdenum, whereas an acid soil of higher total molybdenum content (3·5 p.p.m.) gave a value of 0·5 p.p.m.

It is apparent that this work raises many interesting points in connexion with the treatment of pasture. Investigations are proceeding and will be reported more fully elsewhere. [March 3.

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PRINCIPLES AND APPLICATIONS OF ION EXCHANGE

A SYMPOSIUM on the "Principles and Applications of Ion Exchange" was held at the University of Manchester on March 27 under the joint sponsorship of the Royal Institute of Chemistry, the Chemical Society, the Society of Chemical Industry and the Institute of Petroleum. In addition to the papers contributed, an exhibition of apparatus, with demonstrations, was on view.

In the morning session, on theoretical aspects (chairman, Prof. C. W. Davies, University College of Wales, Aberystwyth), Dr. K. W. Pepper (Chemical Research Laboratories, Teddington) gave the first paper, on "Chemical Structure and Physical Characteristics of Ion-Exchange Materials". He illustrated the concept of ion-exchange resins as insoluble acids and bases by reference to certain aspects of their reactions—for example, equivalence of exchange, reversibility and accessibility of functional groups as exchange sites. After describing the preparation and chemical structure of a number of resins in some detail, particularly the most chemically stable cross-linked polystyrene type, Dr. Pepper gave an account of the characteristic behaviour of the principal types of cation and anion exchangers and indicated the influence of the degree of cross-linking of the polymeric framework on swelling, rates of exchange and equilibria.

In his paper on "Physical Chemistry of Ion-Exchange Equilibria and Kinetics", Dr. J. A. Kitchener (Imperial College of Science and Tech-

nology, London) pointed out that equilibria and kinetics are relevant to practical use of resins since they govern selectivity and speed of operation. Three principal theoretical treatments, complementary rather than contradictory, have been tried involving, respectively, the law of mass action, Donnan membrane equilibrium, and ion exchange as an interaction between individual ions and charged sites. It has become clear that an adequate treatment must make allowance for the work of swelling and particularly for ionic interactions in the resin phase, a matter presenting considerable theoretical difficulty. The kinetics of ion exchange can be broadly explained by a diffusion mechanism; but a detailed quantitative theory in terms of resin structure has not yet been developed.

Dr. E. Glueckauf (Atomic Energy Research Establishment, Harwell) then discussed "Factors Affecting the Operation of Exchange Columns", indicating that while some separations depend on the separating power of the resin, others depend on a complexing produced in the aqueous phase. Resins with higher cross-linking are more suitable for the first type, but a lower cross-linking is better for the second. He referred to the factors, in column operation, which affect the sharpness of chromatographic bands, and distinguished between three different modes of column operation: removal of impurities (as in water softening), displacement chromatography, and development chromatography. The first two lead to fast separations and are preferable for industrial applications, but there is no complete separation into isolated bands. This only happens with the third mode, which lends itself to analytical uses. Dr. Glueckauf mentioned a recent innovation of 'gradient development' which employs an eluting solution of constantly increasing strength.

In the discussion, Dr. Kitchener, replying to Mr. J. A. Dukes, stated that he had referred to the hydrated ion when speaking of the effect of ionic size on exchange kinetics. Mr. D. K. Hale commented upon the large variations in the mass law product which can accompany variations in cationic composition of the resin and quoted supporting results of the cation pair $N(C_2H_5)_4^+$ and H^+, for a sulphonated cross-linked polystyrene. Treatment of the resin with an excess of $N(C_2H_5)_4OH$ causes an irreversible structure-change consistent with a decrease in cross-linking. Mr. Hale also mentioned difficulties which may be encountered when performing chromatographic separations with resins of low cross-linking, and stated that surface sulphonated polystyrene resins may help in difficult separations. Dr. Glueckauf reported experiments by Dr. Barker demonstrating the charged double layer, most pronounced in very dilute solutions, surrounding resin particles. Due to electrostatic repulsion, friction between resin particles is reduced, as shown by the angle of repose of a tilted bed. The effect is not shown by silver resinates.

Dr. D. D. Pratt (director, Chemical Research Laboratories, Teddington) opened the afternoon session on practical applications. In the first paper, on "Practical Applications of Ion Exchange in Water Treatment", Dr. E. I. Akeroyd (Permutit Co., Ltd.) reviewed the various types of ion-exchange materials, their applications in a number of water treatments, and plant and control instruments. He described the deionization of water and discussed the classical two-bed system, the more recent mixed-bed method, and the newer anion-exchange resins which can remove silica and other very weak acids. Dr. J. Hope (Charles Lennig and Co., Ltd.), speaking on "Other Applications", surveyed the uses of ion-exchange materials in the purification of formaldehyde and glycerine, in processing beet sugar, and in the pharmaceutical industry (for example, manufacture of streptomycin). He also described interesting therapeutic applications, such as the treatment of peptic ulcers, heart disease, cirrhosis of the liver, and the estimation of gastric acidity.

In the last paper of the session, on "Laboratory Applications", Dr. J. E. Duncan (Harwell) dealt with three general uses of ion exchange. The first is as adsorbates—for example, in chromatographic separation of ions by direct elution with acids and alkalis, elution with complexing agents, separation of non-electrolytes from electrolytes and separation of trace amounts; such procedures are of interest in both preparative and analytical chemistry and, in the latter case, ion-exchange is easily adapted by a radio-activation procedure and by the isotope dilution method. The other two uses are as laboratory reagents for titration, buffering and catalysis, and as a physico-chemical technique for the determination of ionic charge, ionic concentration, ionic size and molecular size (using dry ion exchangers as molecular sieves). In the last four applications mentioned, a detailed knowledge of the physico-chemical behaviour of the ion exchange is usually necessary.

During the discussion, Dr. B. A. J. Lister briefly described a study of the ionic size, charge and degree of formation of cation complexes in the case of zirconium, and in answer to Mr. E. Foley stated that the hydrolysis scheme for zirconium is not reversible and that hafnium may accompany zirconium in complexes. Dr. Duncan, in reply to Mr. Stevenson, quoted work by Kressman and Kitchener and others on the use of ion exchangers to determine the size of dye molecules. Mr. N. A. Hurt put a question on the removal of ammonia by cation exchangers and its effect on their capacity in water treatment. Dr. Akeroyd stated that 95 per cent of the ammonia could be removed and demonstrated the point of 'break-through' diagrammatically. A question by Dr. E. M. Meade on Sn^{2+}, Cr^{2+} or Ti^{2+} resins as reductors or basic resins in the CrO_4^{2-} or MnO_4^{2-} form for oxidations was deferred to the evening session, in view of the comments to be made by Dr. Fairbrother. Dr. Pepper summarized applications of ion exchange in organic chemistry.

Further developments of ion-exchange materials were discussed at the evening session (chairman, Dr. F. Fairbrother, University of Manchester). Dr. R. E. Kressman (Permutit Co., Ltd.), in his paper on "Ion-Exchange Resin Membranes", described continuous sheets and rods made from both cation and anion exchangers, normally produced in granular form, and, in particular, described electrodes made from a sulphonated phenol type of resin. As expected on theoretical grounds, when these membranes separate two pure solutions, identical except in concentration, E.M.F.'s are set up which, within certain concentration limits, are predicted by the Nernst equation $E = (RT/F) \log a_1/a_2$. After discussing the results obtained—for example, with mixtures of salts, or pure solutions of salts having a common cation and different anions—Dr. Kressman concluded from his work that, within certain limits, the electrodes are useful for measuring the activities of ions in solution of salts, provided they contain one cationic species only.

Dr. Fairbrother next gave a review of the work of Prof. H. G. Cassidy (Yale) on electron exchange polymers as oxidation-reduction systems. Quoting a letter from Prof. Cassidy, he stated that the material described (*J. Amer. Chem. Soc.*) was largely dimer and trimer, believed to be produced by a chain-terminating type of reaction of the Diels–Alder class. In more recent work, yet to be published, high polymer has readily been obtained by acetylating the monomer first, polymerizing in the presence of benzoyl peroxide, and then hydrolysing to yield polyvinyl hydroquinone which can be oxidized and reduced. The titration curve obtained was 'smeared out' in that it showed a greater slope than that of pure hydroquinone. This has been ascribed to the statistical effect of having many oxidizable groups with slightly different energies (due to their fixed location on the chains relative to other groups). Several co-polymers have been made and also cross-linked polymers to bead form.

A written contribution from Prof. M. G. Evans (University of Manchester) on possible interesting future developments with such resins was then quoted by Dr. Fairbrother. Prof. Evans likened the 'smearing out' effect to that obtained on titration of poly-electrolytes of acid or basic resins, and arises from the same causes. He pointed out that the fixing of the centres may increase the concentration of the semi-quinone forms and recalled the early work of Knorr, who found that oxidation-reduction systems adsorbed on protein and cellulose structures appeared to lead to more stable semiquinones. The possibility is opened up of studying, in more detail than previously possible, the specific reactions of such entities, and it is not to be forgotten that the attachment of prosthetic groups to the protein moiety may lead to similar effects. In writing of the relative positions of the groups, Prof. Evans also referred to the possibility of studying co-operative effects, saying that if one could synthesize a resin of which the oxidation-reduction levels formed a band characteristic of the whole structure, one could imagine a process occurring at one end of the structure influencing a coupled oxidation-reduction at a considerable distance away, an interesting possibility which may arise in biological systems. Finally, he commented that the juxtaposition of two reacting centres might speed up oxidation-reduction reactions involving the simultaneous transfer of two electrons, which are normally slow, and there might be an effect similar to that of catalyst structure where a match of pattern becomes important.

Prof. Davies then briefly summarized the applications that had been discussed and pointed out that they ranged over the whole field of the design and utilization of synthetic high polymers for their chemical properties. The term 'ion exchange' has already been outgrown, and many new developments may be anticipated; electron-exchange resins are a subject of interest, and so are specially selective resins, designed to pick out one substance from a high concentration of other ions. Also, the advantage of a column procedure in pushing an equilibrium to completion can be exploited in directions other than in ion exchange—for example, in dissolving sparingly soluble salts or in the chemistry of comparatively stable complex compounds. The possibility of designing materials in which the number, kind and spacing of reactive groups can be predetermined offers a range of models to the theoretical colloid chemist and to the biochemist, who may find the catalytic properties of such materials to be of special interest. Finally, Prof. Davies said, the behaviour and use of ion exchangers in non-aqueous solvents is a subject overdue for development, and may result in laboratory applications of quite a novel kind.

In the concluding discussion Dr. Glueckauf stated that other work by Dr. Barker corroborated the findings of Dr. Kressman on ion-exchange membrane potentials of alkali solutions. Deviations from the theoretically expected potential slope, as yet unexplained, were, however, observed for calcium chloride solutions. Dr. J. D. Bu'Lock, referring to Prof. Cassidy's work and Prof. Evans's speculations on possible biological analogues of electron exchange polymers, directed attention to naturally occurring materials of this type. He cited, for example, melanin, an animal pigment which is a cross-linked polymer of indole-5 : 6-quinone, individual units of which should have different redox potentials, the overall effect being a smoothing-out of the oxidation-reduction curve of the polymer. Natural melanin is bound to protein, forming granules associated with various enzymatic activities. Dr. Bu'Lock suggested that one function of melanin and similar natural products is to provide a suitable environment for the operation of enzymes by a kind of redox buffer mechanism.

INTERNATIONAL SCIENTIFIC RADIO UNION

THE tenth General Assembly of the Union Radio Scientifique Internationale (URSI) will be held in Sydney, Australia, during August 11–23. Of the previous nine meetings of the Union, all have been held in Europe except the second, which took place in Washington in 1927. At the previous General Assembly of the Union, held in Zurich in 1950, Sir Edward Appleton was elected president of the Union and also its delegate to the parent body—the International Council of Scientific Unions. The other officers of the Union appointed at Zurich were: Dr. J. H. Dellinger (U.S.A.), Father P. Lejay (France) and Dr. D. F. Martyn (Australia) as vice-presidents, Prof. Ch. Manneback (Belgium) as treasurer, and Eng. E. Herbays as secretary of the Union, with headquarters in Brussels.

The scientific work of the Union is organized under seven commissions, the titles and presidents of which are as follows: (1) Measurement and Standardization, Dr. J. H. Dellinger (United States); (2) Troposphere and Wave Propagation, Dr. C. R. Burrows (United States); (3) Ionosphere and Wave Propagation, Sir Edward Appleton (Great Britain); (4) Terrestrial Atmospherics, Prof. H. Norinder (Sweden); (5) Radio-Astronomy, Dr. D. F. Martyn (Australia); (6) Waves and Circuits, Prof. B. van der Pol (Director, C.C.I.R.); (7) Electronics, Dr. G. Lehmann (France).

The British National Committee for Scientific Radio is organized under the auspices of the Royal Society as a constituent member body of the Union Radio Scientifique Internationale. This Committee has nominated the following British delegation to the forthcoming general assembly, the numbers of the commissions to which they are specially responsible being indicated in brackets: Sir Edward Appleton (president), Dr. W. J. G. Beynon (3), Mr. J. A.

Ratcliffe (4 and 7), Mr. F. G. Smith (5 and 6), Dr. R. L. Smith-Rose (1, 2 and Executive Committee).

It is understood that Profs. S. Chapman and H. S. W. Massey will also attend the meeting in Sydney by special invitation.

In accordance with established procedure, the various national committees will submit reports to the General Assembly reviewing the advances made within their own countries in each of the fields of research indicated by the seven commissions. As the results of this work may have an important bearing on associated scientific fields and also on the practice of radio communication, the Union is represented on several other international scientific bodies and also on the appropriate study groups of the Comité Consultatif International des Radiocommunications (C.C.I.R.). This arrangement forms a very satisfactory liaison whereby the fundamental problems confronting the practical radio engineer are brought to the notice of the astronomer, meteorologist and radio-physicist, and whose results can be quickly applied to communications technique.

BRITISH CAST IRON RESEARCH ASSOCIATION

By Dr. J. G. PEARCE, O.B.E.
Director

A FURTHER stage in the progress of the British Cast Iron Research Association was reached on July 2 when the president, Dr. J. E. Hurst, formally opened some extensions additional to those previously reported (*Nature*, 166, 261; 1950). These include chemical and spectrographic laboratories, sands laboratory, heavy stores, and accommodation for operational research, development, and work on foundry atmospheres. A fuels and furnaces building is under construction.

The spectrographic laboratory houses a quantometer, an American direct-reading spectrograph, which is channelled to permit estimations of twelve elements occurring in the cast iron alloys, and which is expected to record the elements spectrographically determined in normal material within one minute. The instrument comprises a high-precision source unit built to reproduce almost any type of electrical discharge, a spectrometer measuring through a photoelectric cell system, and a console recording the photocell current through an electronic system. The use of the instrument was demonstrated, although it is not yet fully calibrated. The technique for the spectrographic determination of elements in cast iron was published by the Association in 1948, its application to the less common elements in 1949, and to foundry slags in 1952. It is anticipated that it may be possible to determine both carbon and also phosphorus (not usually determinable by spectrographic analysis), the only element of those normally required that is still incapable of spectrographic determination being sulphur.

It is not practicable to review in detail the whole of the work accomplished and in progress; but some indication of its scope is given by the fact that during the past two years the Association's *Journal of Research and Development* has published seventy-nine reports, including reports presented to a number of conferences held for members during this period.

The establishment of practical foundry processes since 1948 for producing nodular graphite in the as-cast state by means of cerium or magnesium is now a matter of history. Certain difficulties in effecting perfect nodulization by magnesium, thought to be due to interfering elements, have now been resolved. The Association has established the subversive elements concerned, the range beyond which they are troublesome, and that their ill effects can be removed by the use of cerium in conjunction with magnesium. The Association's research manager, Mr. H. Morrogh, has recently received the McFadden Gold Medal of the American Foundrymen's Society for his work in developing nodular graphite iron. These processes have raised very difficult analytical problems for both the chemist and the spectrographer, on account of the very small amounts concerned, not only of the elements used for securing the nodular structure, added and residual, but also of the interfering elements. The vacuum fusion method is employed for the determination of gases.

An investigation into the fluidity of cast iron has been completed, and active work is proceeding on the vitreous enamelling of cast iron, on chilled irons, and on shrinkage and porosity, these latter defects being studied with the aid of gamma rays.

In the field of moulding sands, the emphasis has moved to a study of the properties at elevated temperatures, at which, of course, they are used in practice. Special apparatus has been acquired for this purpose from the United States, and the Association has designed and built its own apparatus for evaluating the stress-strain characteristics of sand aggregates, both at ordinary and at elevated temperatures, and has already related the results to certain common defects due to sand. High-frequency heating is used for giving temperatures required before the sand bond can be affected by the heat. The property known as 'flowability' is being studied, and considerable work has been done on the use of synthetic resins as bonding materials. These resins are used in the shell-moulding process, which has excited considerable interest in foundry circles, the normal mould being replaced by a thin shell of resin-bonded silica sand.

Progress has been made on the study of foundry atmospheres, particularly with reference to the presence of toxic gases and the measurement of dust and dust movement; in particular, the conventional system of hood-extraction used on pedestal grinders, commonly used in foundries for cleaning castings, has been shown to be entirely inadequate. A design has been evolved by the Association, involving the use of high-velocity air streams above and at the side of the working area, using less power than the normal system, and keeping the breathing zone of the operator clear of dust to a remarkable degree. Co-operation with manufacturers is being arranged.

The Operational Research Team set up in 1950 for visiting foundries with the object of recommending steps for promoting production efficiency has now made more than two hundred visits and collected considerable information. The iron-founding industry is operating in the United Kingdom at a record level of output, approaching 4 million tons of iron castings per annum, employing 150,000 people, and the output per man per annum has increased materially in recent years, by some 28 per cent since 1945 and some 13 per cent since 1948, in spite of difficulties relating to raw materials and personnel.

LACE RESEARCH ASSOCIATION

NEW CENTRE AND LABORATORIES

THE new centre and laboratories of the Lace Research Association at Glaisdale Drive, Bilborough, Nottingham, were formally opened on May 15 by Sir Cecil Weir, and after the ceremony a large number of members of the Association and their guests inspected the work being carried out in the laboratories.

The lace industry of Great Britain is a small but highly specialized, and economically important, industry situated mainly in Nottingham and the surrounding districts; all types of lace are manufactured there, but centres are also to be found near Kilmarnock in Scotland, where the product is lace furnishings, and in the west of England, where plain nets are made. There are very few large firms, the industry consisting in general of small unit firms, some three hundred in number, and the average size is of the order of ten machines. The working force varies between ten and fifteen thousand employees, of which, compared with the other textile industries, a very high proportion is made up of male workers. The conversion value of lace from the raw fibre to the finished fabric is exceedingly high; the trade is worth £10–15 million a year and is concentrated mainly on the export market, certain sections exporting as much as 98 per cent of their products.

The industry consists of six separate branches manufacturing the following types of product: plain net section—all types of plain and figured nets, including dress nets, tulle, mosquito nets, sand-fly netting, etc.; leavers lace section—fancy laces, hair nets, veilings, trimming laces, etc.; lace furnishings section—curtains, table and bed furnishings, etc.; warp lace section—lace produced on a multi-thread warp lace knitting-machine; barmen section—narrow lace and braiding; and embroidery section—pattern lace produced on multi-needle 'schiffli' machines, either on a base of plain net or on a dissoluble fabric. Nearly all the common textile fibres, both natural and synthetic, are used, or can be used, in the industry, but the principal fibre is, of course, cotton. An important subsidiary part of the industry is that concerned with the dyeing, dressing and finishing of lace; these operations are confined to a small number of firms which have the necessary specialized skill, experience and machinery.

The building of lace machines is a highly specialized branch of engineering, and Nottingham is naturally the world centre. In general, the machines are very large, those in the leavers section of the industry being of the order of 200 in. in width, while in the lace furnishing section there are several producing lace of up to 480 in. in width.

The idea of setting up a research organization for the lace industry was first mooted in 1943, and in March 1944 a research committee was formed by the Federation of Lace and Embroidery Employers' Association. From this development a Lace Federation Research Council was started, which was recognized by the Department of Scientific and Industrial Research as a grant-earning body, and a small research staff was assembled in temporary premises in Nottingham. After further discussions with all the interested trade bodies, it was decided to take advantage of the Industrial Organization and Development Act and to raise money for the formation of a research organization by means of a statutory levy from all the manufacturing sections of the industry. The Lace Research Association was finally incorporated in October 1949, and took over, in expanded form, the functions of the Lace Federation Research Council. The Association is financed in part by the proceeds of the statutory levy, in part by subscriptions and in part by a government grant based on the income from industry. Generally speaking, it is very well supported by the trade, and its total basic income is of the order of £17,000 a year.

The new building of the Association consists of administrative and laboratory space amounting to approximately 3,800 sq. ft. The front portion contains the library and council room, director's office, general office and textile-testing room. In the laboratory wing are physics and chemistry laboratories, a dark room, engineering workshop, operational research section, store rooms and offices, and a small canteen and kitchen; this wing is built so as to allow for future expansion, the partitioning being easily altered, and running below the main corridor is a trench carrying all the necessary services, with subsidiary trenches into the individual laboratories. To the rear of the site is a separate building with floor space of 2,000 sq. ft. which holds full-scale narrow-width lace machines and certain auxiliary equipment, and in which experimental and development work on the production side may be undertaken; this building is well insulated and is electrically heated with thermostatic control to maintain a steady temperature. The research work in the laboratory wing has up to now been chiefly concerned with two problems. In the first, a new type of Jacquard string known as 'Lacra' string has been developed which does not change appreciably in length with varying humidity (caused by changes in the weather). These strings are of high-quality linen thread and are used in the Jacquard pattern-forming mechanism of lace-furnishing machines. As the strings are of different length, a certain percentage change due to variation in the humidity will cause different overall changes in length and the pattern will be distorted. The new string has now been in service on a number of machines for some time and is proving highly successful. The other research development has been the production of a new lubricant in place of the powdered graphite normally used for lubricating the fine working parts of a lace machine. Graphite has the disadvantage that, being black, it causes considerable dirt in the factory and soils the lace. A new lubricant, the composition of which is at present a secret, has been developed which allows the production of fabrics which are quite white.

As might be expected, a cordial spirit exists between the research staff, headed by J. C. MacCallum as director of research and secretary of the Association, and the University of Nottingham. Three Nottingham professors serve on the council of the Association, and one of them, Prof. L. F. Bates, is vice-chairman of the Research Control Committee. Relations are also maintained with the Nottingham and District Technical College. This co-operation between the research organization of an industry that has a very strong regional background with the educational and technical-training services of that region is certainly a very happy feature of the Association, and it augurs well for the quality of the scientific and technical work that can be expected from the new laboratories.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

New Procedures for Resolution of Racemic Substances

EXCEPT for Pasteur's original procedure of sorting crystals by hand, the methods practised or suggested for the preparation of substances in optically active form depend on the use of a dissymmetric substance in one of its enantiomorphous forms or on the application of some dissymmetric influence. A recent extension[1] of the hand-sorting process does not require the use of *d*- or *l*-materials or sorting of crystals by enantiomorphous faces. It has been applied only to trithymotide, a substance of molecular constitution lately elucidated[2]. A second extension now applies to a range of substances.

In the first method, a racemic substance forms a crystalline molecular compound with an optically *inactive* substance. The van der Waals forces that normally hold the *d*- and *l*-molecules together as a crystalline racemate are overcome in a rearrangement involving the second component. Instead of *dl*, there crystallize from the solution *Ml* and *Md*, where *M* is the optically inactive substance. This has been found with trithymotide, which forms a series of molecular compounds $2C_{33}H_{36}O_6.M$, where *M* may be benzene, chloroform or a large variety of other substances. Most of these molecular compounds are spontaneously resolved.

The optical activity is demonstrated by the growth of one large crystal or an equivalent crop of crystals all derived from the same seed. No enantiomorphous faces develop; but the crystal is known from X-ray diffraction experiments to belong to an enantiomorphous space group and to contain trithymotide molecules of one hand only. Its solution rotates the plane of polarization of light. The trithymotide racemizes rapidly in solution, and therefore the slow growth of a single crystal or homogeneous crop may be controlled so that all the trithymotide is removed in the *d*- or *l*-form, depending on the nature of the seed. Similar resolutions, not necessarily accompanied by racemization, may be expected. When a *dl*-substance forms a crystalline molecular compound with an optically inactive substance, *d*- and *l*-molecules may enter in equal numbers into the structure, and in this case it will not be resolved; but since to form any molecular compound the normal mode of union of *d*- and *l*- must be disturbed, the chance of spontaneous resolution is increased. Any molecular compound that a *dl*-mixture may form therefore seems more likely to be spontaneously resolved than its parent substance.

The second method is suggested by the behaviour of trithymotide described above. The closely related crystal structures of its molecular compounds contain as the second component such varied molecules as carbon disulphide, benzene, ethanol, *n*-propyl iodide or chloroform, and retain this sometimes volatile component very tenaciously. In this they resemble the clathrate type of compound[3], and the structure must consist of an arrangement of trithymotide molecules enclosing a set of cavities. Whether these spaces are closed or open and whatever their precise form may be, the surrounding molecules, which are all *d*- or all *l*- in any one crystal, impose on the cavities a form which is not identical with its mirror image. If, therefore, trithymotide is crystallized from a solvent which is itself a *dl*-mixture and forms with it a molecular compound similar to those discussed above, the cavities of any one crystal will enclose preferentially the *d'*- or *l'*-form of solvent molecule. Any process for separating the *d*- and *l*-trithymotide should separate *d'*- and *l'*- simultaneously.

The process has been applied to resolve secondary butyl bromide. In one experiment a single crystal was grown and in others homogeneous crops were developed from a single seed crystal by repeated division and growth. The crop when dissolved in chloroform showed a large − rotation due to trithymotide. This decayed rapidly through racemization and left a much smaller permanent − rotation due to the secondary butyl bromide.

With trithymotide the method is applicable to a range of substances; but it may be expected to fail with molecules which are too large for the cavities. It could be extended by the discovery of substitutes for trithymotide. Where it is applicable this method of resolution has advantages that may be of importance. Chief of these is that no chemical reaction is involved in the process and no change of configuration can occur. Since sorting is on the basis of molecular shape and space requirements only, there is no need for a reacting group in the molecule. It could, for example, be applied to paraffins. By suitable modification very small amounts of material may be separated. The optical rotation initially observed when a crystal of the molecular compound is dissolved is due to the trithymotide, and may be hundreds of times greater than that of the resolved substance. Observation of the sense of this initial rotation therefore will provide a means of sorting a quantity of material too small to show its own rotation. Still smaller amounts might be handled in mixtures with a carrier solvent. If both carrier and solute enter into the molecular compound formation, sorting by any process should resolve the rare constituent which occupies a few of the cavities. In the special case where the carrier solvent is *d*- or *l*-, only one of the enantiomorphous crystals can develop and no sorting is necessary. From one known absolute configuration of a molecule that is enclosed by trithymotide, and a detailed structure determination, it is possible in principle to determine the absolute configuration of the cavities corresponding to each enantiomorphous form of the crystal. These being known, the absolute configurations of some other molecules could be deduced from observation of the form of trithymotide with which they combined to form the molecular compound.

Both the methods show how spontaneous production of unequal amounts of *d*- and *l*-forms can occur, and illustrate the preferential incorporation of one form in a growing structure. It is possible that somewhat similar processes may be responsible for the original dissymmetry in the chemistry of living matter and for its perpetuation.

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May 20.

[1] Newman, A. C. D., and Powell, H. M., see reference (2) footnote, and *J. Chem. Soc.* (in publication).
[2] Wilson Baker, Gilbert B., and Ollis, W. D., *J. Chem. Soc.*, 1443 (1952).
[3] Powell, H. M., *J. Chem. Soc.*, 61 (1948).

Natural Moisture-content, Porosity and Compaction of Clayey Deposits

It seems desirable that attention should be directed to the very discordant figures for porosity (or void-ratio) of clayey sediments that are yielded by the two different methods of determination that may be adopted, namely, by direct measurement or by calculation from the natural moisture-content. I cannot but think that the discrepancies must have been commented on during the past two decades as knowledge of natural moisture-contents steadily grew; but my inquiries have failed to produce any reference to a published discussion of their implications.

In the following paragraphs the symbols m and n are those used in geotechnical (soil-mechanics) laboratories, m for the natural moisture-content expressed as grams of water per 100 gm. of solid dried to constant weight at 105–110° C., and n for the porosity calculated from m and expressed in the usual manner as the percentage of the total volume occupied by voids. The symbol P is retained for the porosity determined directly by the standard methods. The void-ratio e is the volume of voids to the volume of solid.

The evaluation of m presents no difficulties; but precautions are necessary to ensure that the samples when tested are as nearly as possible in their natural 'undisturbed' condition (in the engineering sense). Weathered or obviously fissured samples are rejected. Sediments lying below the ground-water table are known to be, with few exceptions, saturated down to a considerable depth, although the precise limit is in doubt. All the samples here referred to came from this zone of saturation.

A small but representative selection of values of m, n and P for some British clayey sediments is given in the accompanying table.

	m	n	P
Pleistocene bedded clay	50	57 per cent	31 per cent
Tertiary clays	28	43	29
Upper Cretaceous Gault	29	44	24
Jurassic, Lias	22	37	24
Triassic, Keuper	12	24	12
Coal measures, shale	13	26	10

By way of contrast to the discordant values shown in the last two columns, the results for n and P in the case of a fine-grained calcareous material such as the Upper Chalk reveal no discrepancy. The mean of a number of values obtained by different investigators with samples from various parts of the country is closely 44 per cent for both n and P. It will be observed that this figure falls into its appropriate place in the age-sequence, between the Tertiary clays and the Gault, in the column for n, but not in that for P.

Since the determinations of m and P for sediments from other European countries and from America, so far as I have been able to trace them, are of the same order of magnitude, horizon by horizon, as those listed in the table, and since the procedure followed is similar, there seems no escape from the conclusion that the standard method of directly determining porosity is not suitable for materials containing an appreciable quantity of clay. It is not feasible to allow sufficient time in the laboratory for the restoration of the structure which previously existed in or around the clay-mineral lattices but which was destroyed when the samples were dried.

It should be noted that the volume-shrinkage caused by drying of the test-specimens seems to be inadequate, at least in most cases, to account for the difference. Even if it did so, the objection to the use of the low P values still remains.

That such low values should have been recorded for P will probably not surprise those familiar with the physical changes in clayey materials (for example, loss of plasticity, lowering of liquid limit, increase of grain-size, etc.) produced after even short periods of air-drying.

The porosities vary, of course, according to which particular clay-mineral species is dominant. In due course, we may hope to compile a table for each dominant species. The few figures that are available for montmorillonoid clays indicate that they will fall into a separate series with values of n much higher (as their swelling capacity would suggest) than those in the above table. Passing reference may also here be made to the abnormally low porosity of boulder clay, first discovered by H. C. Sorby and ascribed by him to exceptionally high compression, possibly by ice-load. The determinations of m have confirmed his observations. An average figure for m is 15, whence n is 28 per cent, Sorby's value for P being 24 per cent. The discrepancy here is smaller than in the case of the other clays mentioned, possibly because of the very different mineralogical composition, the quantity of silt and rock-flour in the matrix being usually considerable.

From the values of P set out in the table, and from other similar direct determinations by the standard methods (for example, on air-dried cuttings from deep well drilling) the void-ratio e appears to be only a third to a half its true value as calculated from m. If additional records confirm this, many inferences that have been drawn from the erroneous figures for e will need to be revised, and calculations relating to depth of burial, gravitational pressures, compaction, bulk-density and volumes of sediments may require substantial adjustment.

Many other interesting problems are presented by the records of m that have already accumulated. Since these are all too few, however, it is to be hoped that full advantage will be taken of the exceptional opportunities for collecting and testing clayey sediments at present afforded by numerous engineering undertakings and programmes of exploratory and other borings distributed widely throughout Great Britain.

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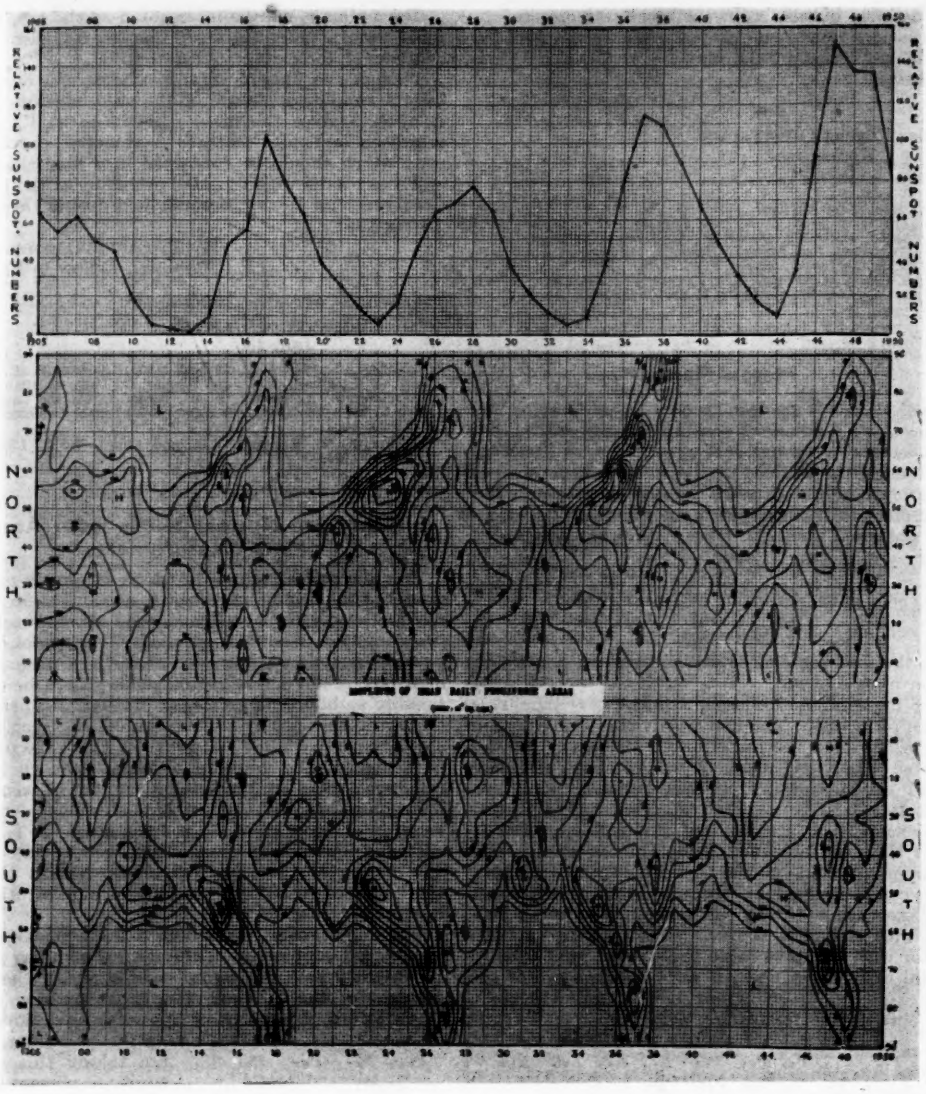
Prominence Activity and the Sunspot Cycle

The relationship that exists between the distribution and frequencies of prominences at the limb of the sun and the sunspot cycle has been discussed by several workers[1]. The most outstanding feature is the existence of two distinct zones of prominence activity in each hemisphere. The low-latitude zones extending from the equator to about 50° are always present, although prominence activity in these zones is least at the epoch of sunspot minimum. The high-latitude zones have a different life-history. Prominence activity in these zones drops very suddenly and becomes quite inconspicuous shortly after sunspot



maximum. About four years thereafter, a centre of activity develops at about latitude 45°–50°. The activity undergoes a rapid increase and at the same time the prominences extend to higher latitudes. The high-latitude zones become fully developed at the epoch of sunspot maximum.

Photographic observations of solar prominences in the *K* line with the spectroheliograph were commenced at Kodaikanal in 1905. The material available up to date covers four sunspot cycles. The Kodaikanal data for the period 1905–14 have been discussed by Mr. and Mrs. Evershed, while the data for the period 1905–28 have been discussed by W. Moss. Half-yearly summaries of prominence observations are published in the *Bulletin of the Kodaikanal Observatory*.

From the mean daily profile areas of prominences computed for each 5° latitude zone, I have prepared the accompanying diagram, which brings out strikingly the relationship between prominence activity and sunspot cycle during the period 1905–50. The contour lines are drawn at intervals of 50×10^{-3} sq. min. of arc of prominence area. Regions of maximum activity are marked *H*, and those of minimum activity *L*. There is some resemblance between this diagram and the well-known 'butterfly diagram' of Maunder. Attention may be directed to an interesting point brought out by this diagram. It is well known that the sunspot maximum of 1947 is one of the highest on record. However, prominence activity has been much less during the latest sunspot cycle as compared with the two previous cycles. The diagram also shows that the region of most intense prominence activity on the sun occurs at about latitude 50°–55° in both hemispheres some three or four years before sunspot maximum.

A detailed discussion of the results of prominence observations made at Kodaikanal during 1905–50 will be published in the *Bulletin of the Kodaikanal Observatory*.

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Meson Masses

The classical electron radius r_e is defined by $e^2/r_e = m_e c^2$. A sphere of constant density with radius r_e possesses a radius of gyration $r_g = (0{\cdot}4)^{1/2} r_e$. The energy eigenvalues of the rigid rotator are not yet known in the extreme relativistic region; but there one can quantize with integers k as for circularly polarized photons: thus $r_k p_k = k\hbar$. For $k = 1$ and $r_1 = r_g$ it can be deduced that:

$$m_1/m_e = p_1/m_e c = \hbar/m_e c r_1 = \hbar/m_e c r_e\,(0{\cdot}4)^{1/2} = 137 \times 1{\cdot}58 = 216{\cdot}6. \quad (1)$$

Thus the first rotation level compares with the first meson mass 212 m_e.

The mass of the π-meson requires $r_g = \frac{1}{2} r_e$. This is true for a disk. The non-relativistic eigenfunction P_1^1 consists of a section through the axis. In the extreme relativistic region it will contract and may indeed degenerate into a disk rotating about an equatorial axis.

Levels with $k > 1$ are not impossible. But it seems that the observed higher meson masses can be approximated better by quadratic relations. These can be derived, for example, if one assumes that a sphere with radius r_e can contain n rotators in a row, with radius $r_n = r_e/n$. According to (1), one rotator with radius r^n has a mass nm_1. This leads to a total mass $m_n = n^2 m_1$, if all n rotators are of the same kind ($r_g = 0{\cdot}632 r_n$ or $r_g = \frac{1}{2} r_n$, and $k = 1$). One obtains the following masses:

	$P_{1,0}$	$P_{1,1}$	$P_{2,0}$	$P_{2,1}$	$P_{2,2}$	$\Delta_{2,0}$	$\Delta_{2,1}$	$\Delta_{2,2}$	$\Delta_{3,2}$	$P_{3,0}$	$P_{3,1}$	$P_{3,2}$	$P_{3,3}$	$P_{4,0}$
Calc.	216·6	274	866	981	1,096	1,400	1,523	1,647	1,771	1,949	2,121	2,293	2,466	3,464 m_e
Obs.	212±5	275	796	967	1,125	1,370	1,510				2,203			
	μ	π	V_2	τ	$\varkappa_2$	$\varkappa_4$	$\varkappa_1$				V_1			

The systems are called $P_{n,m}$. The first index specifies the number of rotators contained in the sphere; the second suffix indicates how many rotators possess $r_g = \frac{1}{2} r_n$. The same principle allows the arrangement of three rotators in an equilateral triangle (called Δ), or of four in a tetrahedron (T) within a sphere of radius r_e.

The first seven levels of this scheme seem to have been observed[1]. V_1 compares with the mean of P_3 or T_4 ($T_{4,2} = 2{,}183\ m_e$). $\varkappa_1 = 1{,}510$ or 1,550, according to Von Friesen. The observations by Leighton *et al.*[2] can be taken as further evidence for masses $P_{2,0}$, $P_{2,2}$ and $\Delta_{2,1}$.

Incidentally, the proton mass can be obtained if two rotators of the system $\Delta_{3,3}$ gyrate around a twofold symmetry axis. This gyration may, as in ortho-hydrogen, be stabilized by spin symmetry.

The radius r_e can be interpreted as the range of a force with a potential steep enough to balance the centrifugal force due to rotation.

Though the present rotator scheme can represent only a simplified picture of the true eigenfunctions, it already gives the masses of the μ, π, V, τ and $\varkappa$-mesons and has features (symmetry characters, etc.) which should be contained in a final theory.

These results were reported originally at the Bristol Conference on Heavy Mesons, held during December 18–20, 1951.

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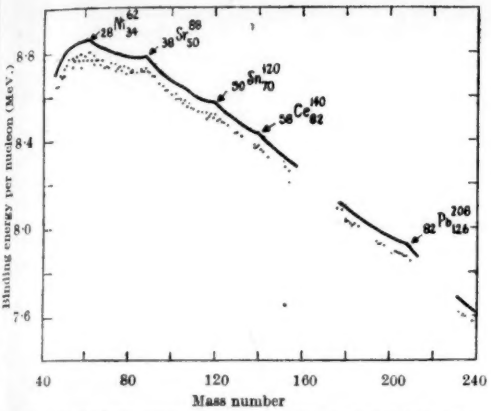
Evidence for Nuclear Shells from Atomic Mass Measurements

The successful manner in which the single-particle model of the atomic nucleus has accounted for many nuclear properties is well known to those who follow developments in nuclear physics. This model, which pictures nuclei as constituted of shells of protons and neutrons, predicts that closed shells should be exceptionally stable configurations. Both experiment and theory (in that order) have indicated that such closed shells occur[1] with 2, 8, 20, (28), 50, 82 or 126 protons or neutrons. In addition to these primary 'magic numbers', there are predicted a number of secondary ones, marking the closure of sub-shells; but the location of most of these is debatable. It is to be expected that certain mass effects are associated with the closing of these nuclear shells, and it is with this subject that the present communication is concerned.

For some time we have been making mass spectrographic measurements of the masses of many of the heavy nuclides, with the view of studying the gross features of the binding energy per nucleon curve. Descriptions of portions of this work have appeared[2] in the literature. We are taking this opportunity to present briefly the significant results of our investigations to date, some of which are based on unpublished work, while others appear only when the data are examined *in toto*.

In the accompanying graph, the binding energy per nucleon is plotted against mass number for approximately 115 of the heavier stable nuclides ($Z > 21$). About half these values have been obtained mass spectrographically, while the remainder have been computed from these using disintegration, transmutation and microwave absorption data. On this plot the completion of a nuclear shell should be indicated by a sudden change in the slope, in keeping with the view that a completed shell represents an exceptionally stable configuration to which additional nucleons are rather loosely bound. The fact that such sudden changes in slope are found experimentally can be seen from the graph. Attention will now



Curve of binding energy per nucleon for stable nuclides with $Z > 21$

be directed to certain of these breaks in the curve which have special significance.

(1) There is the well-known break in the curve occurring at $_{82}Pb^{208}_{126}$, presumably due to the completion of the 82-proton shell *and* the 126-neutron shell. The change in nuclear stability in the lead region was observed[2] by Dempster many years ago and is, of course, borne out by the fact that all nuclides heavier than Pb^{208}, with the single exception of its neighbour $_{83}Bi^{209}_{126}$, are radioactive.

(2) Clearly shown is the sudden break in the region of mass 90, which is to be attributed to the closure of the 50-neutron shell. This sudden change in slope appears to occur at $_{38}Sr^{88}_{50}$.

(3) There is an unmistakable break in the 82-neutron region, probably located at $_{58}Ce^{140}_{82}$.

(4) The stabilizing effect of the 50-proton configuration has a pronounced effect on the curve, giving rise to a definite plateau which breaks off at or in the neighbourhood of $_{50}Sn^{120}_{70}$.

(5) The maximum of the curve occurs at $_{28}Ni^{62}_{34}$. It may or may not be significant that the maximum is located at this particular isotope of nickel, but it is almost certainly significant that it is an isotope of nickel, the proton number of which is 28.

These five features of the curve of binding energy per nucleon against mass number for the heavy masses are now well authenticated. In addition to these, as can be seen in the graph, there are suggestions of other fine structures which need more careful study and, also, there are several unexplored regions. It is gratifying that the present results are concordant with the predictions of the single-particle model. They should be useful in determining the magnitude of the closed-shell contribution to the stability of the nucleus.

It should be noted that A. O. C. Nier and his group at the University of Minnesota and S. A. Goudsmit and his group at Brookhaven have measured[4] many heavy atomic masses in the past few months. The agreement between these recent results and ours is generally satisfactory. The accompanying graph, however, is based, so far as the mass spectrographic work is concerned, on measurements made in our own laboratory. This set of values is more likely to be internally consistent than one compounded from several sources and, also, for a large number of the nuclides shown in the graph, our masses are still the only ones available.

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Polarization Field and the Acoustic Modes of Oscillation of Alkali Halide Crystals

IN a recent paper[1], the frequency of the principal lattice oscillation of an alkali halide crystal, in which the lattice of the alkali ions oscillates with respect to the lattice of the halide ions, was calculated on the basis of the simple Born model. It was found that the electric polarization of the crystal that accompanies this oscillation leads to a polarization field of the Lorentz type which tends to increase the relative displacement of the two lattices and has thus a marked influence on the principal frequency. Microscopically, this polarization may be regarded as due to small dipoles located at the lattice points. Because of the small amplitude of the oscillation, these dipoles will be practically point-dipoles, and since they are also cubically arranged, the polarization field will have just the Lorentz value, namely, $4\pi/3$ times the polarization per unit volume. (Indeed, this appears to be the only case where the conditions postulated by Lorentz for obtaining the factor $4\pi/3$ are rigorously satisfied.)

The important part which the polarization field plays in determining the resonance frequency of the crystal is indeed to be expected from other considerations. Let us consider, for example, the dielectric constant of the crystal, and confine attention to the contribution from the relative displacements of the positive and the negative ions, as distinguished from the electronic polarizations of the ions themselves. Then the effect of the polarization field on the dielectric constant may be taken into account in two alternative ways. We may regard the effective field that produces the polarization as consisting of not only the 'field in the medium', but also the polarization field, in which case we obtain a formula of the Lorentz type:

$$\frac{K_\omega - 1}{K_\omega + 2} = \frac{C/3}{\Omega_i^2 - \omega^2}, \qquad (1)$$

in which Ω_i is *not* the resonance frequency of the crystal but a certain hypothetical frequency which the crystal would have, had there been no polarization field to affect it. Resonance will occur when the right-hand side of (1) tends to unity, that is, when

$$\omega^2 \to \omega_i^2 = \Omega_i^2 - C/3. \qquad (2)$$

Alternatively, we may regard the effect of the polarization field as confined wholly to changing the hypothetical frequency Ω_i to the actual resonance frequency ω_i of the crystal, in which case we obtain the Drude formula:

$$K_\omega - 1 = \frac{C}{\omega_i^2 - \omega^2}, \quad (3)$$

in which C has the same value as in (1).

The relation between the two frequencies ω_i and Ω_i may also be expressed in the form:

$$\Omega_i^2 = \omega_i^2 \left(\frac{K_0 + 2}{3}\right), \quad (4)$$

or more generally,

$$\Omega_i^2 - \omega^2 = (\omega_i^2 - \omega^2) \left(\frac{K_\omega + 2}{3}\right). \quad (5)$$

The acoustic modes of oscillation also lead to a finite polarization of the crystal, since the amplitudes of the two ions are in general different, as a result of the difference in their masses. Though the polarization now is much smaller than in the optical oscillations, the resulting polarization field is still comparable with the field due to the electrostatic and the repulsion interactions between the ions displaced by the acoustic wave.

We have studied the effect of this polarization field on the low-frequency acoustic oscillations in detail, and we find that the polarization field affects considerably the relative amplitudes of the two ions, but their frequencies remain completely unaffected by it (unlike the optical frequencies). This is very satisfactory, since otherwise the well-known Christoffel relations connecting the velocities of propagation of acoustic waves in the crystal with its elastic constants will be disturbed.

Note added in proof, June 30. Detailed investigations on the effect of the polarization field on the acoustic modes of oscillation have since been published (Krishnan and Roy, *Proc. Roy. Soc.*, A, **210**, 481 (1951)).

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Direct Calculation of Viscosities of Liquids

In my viscosity equation for liquids[1]:

$$\eta = \frac{hNb}{V^{2/3}(V-b)^{4/3}} \cdot \exp(1{\cdot}091\,\gamma V^{2/3} N^{1/3}/RT). \quad (1)$$

η is viscosity, V is molar volume, γ is surface tension, T is the absolute temperature, h is Planck's constant, N is the Avogadro number, R is the gas constant and b is the volume occupied by the molecules in the liquid state per mole. It was shown that $b \approx 0{\cdot}33\,V_c$, V_c being the molar critical volume, and that b was a function of temperature. It appeared to me that a direct calculation of viscosity was possible if only b could be obtained by a method not involving viscosity, as all other values on the right-hand side of the equation could be independently obtained.

Applying the equation to benzene and carbon tetrachloride, which have widely differing chemical constitutions, gives results shown in the accompanying table. These indicate that although b and V are both functions of temperature, $(V - b)$ is practically independent of temperature. An analogous constancy of $(V - b)$ values is obtained with other normal liquids such as chloroform (8·37), carbon disulphide (0·38), etc. The necessary data for computation have been taken from the International Critical Tables, any data not directly recorded therein having been calculated from reliable formulæ given in the same Tables. The constancy of $(V - b)$ observed here is rather surprising in view of the fact that it is contrary to the existing views about the behaviour of liquids. Perhaps the term $(V - b)$ as used here is an oversimplified expression, which should await further clarification.

Temperature (° C.)	$V - b$	$\eta_{obs.}$	$\eta_{calc.}$
Benzene			
0	9·36	$9{\cdot}00 \times 10^{-3}$	$8{\cdot}81 \times 10^{-3}$
10	9·49	7·57	7·57
20	9·56	6·47	6·50
30	9·55	5·61	5·63
40	9·58	4·92	4·95
50	9·64	4·36	4·38
60	9·54	3·89	3·90
70	9·48	3·50	3·50
	Mean 9·52		
Carbon tetrachloride			
7·15	7·13	$1{\cdot}19 \times 10^{-3}$	$1{\cdot}27 \times 10^{-3}$
21·21	7·17	0·95	0·94
35·21	7·21	0·79	0·79
49·51	7·20	0·66	0·66
62·87	7·22	0·57	0·57
74·16	7·25	0·50	0·51
	Mean 7·20		

The next step is to compare values of $V - b$ obtained from my equation with those obtained by other methods. A good review of various methods for estimating free volumes in the liquid state has been given by Fowler and Guggenheim[2]. From the coefficient of thermal expansion and the compressibility, for a large number of liquids with non-polar molecules[2], $V - b \simeq 8$ c.c./mole. Such values are in good agreement with those obtained from my equation for benzene, carbon tetrachloride and chloroform[2], but not for carbon disulphide.

From the formula given by Lennard-Jones and Devonshire[3] and its analogue by Eyring and Hirschfelder[4], Fowler and Guggenheim[2] give for chloroform at ordinary temperatures, as a typical example, $V - b \sim 0{\cdot}44$ c.c./mole. This value is considerably lower than that obtained either by my equation or from the ratio of the compressibility and coefficient of thermal expansion[2]. But, for carbon disulphide, for which $V^{2/3}$ is not much different from that for chloroform, the value of $V - b$ from the formula under consideration is in good agreement with that from my equation.

Fowler and Guggenheim[2] describe another method of estimating free volume from the vapour pressure; choosing chloroform at its boiling point as a suitable illustration, they find $V - b \sim 1$ c.c.

Eyring *et al.*[5] utilize the velocity of sound in liquids to obtain the free volume by a formula which gives, for benzene at 15° C., $V - b = 0{\cdot}49$ c.c.

We thus see that the values of free volumes obtained by different methods are not only not concordant but also they are often widely divergent. However, it may be concluded that the values of $V - b$ from the viscosity of my equation are of a reasonable order of magnitude.

Viscosities have been calculated from my equation by using the mean value of $V - b$ empirically de-

termined from the equation and recorded in the table and by substituting all the values for the symbols on the right-hand side of the equation. The results show that the agreement between the calculated and the observed values of η is good provided that $V - b$ is correctly chosen. Further, since $V - b$ is found to be independent of temperature, using my equation as the basis, if a reliable value is available for one temperature, viscosity at other temperatures can be calculated directly with a reasonable degree of accuracy. However, a clear interpretation of the $V - b$ term is needed and further work in this connexion is in progress.

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Effect of Drying upon the Absorption Spectra of Hæmoglobin and its Derivatives

It was shown by Zeynek[1] that on drying deoxygenated hæmoglobin *in vacuo* at 40°, its characteristic one-banded absorption spectrum is replaced by that of a hæmochromogen with two bands at 556 and 528 mμ, the first band being much stronger than the second. On re-introducing water containing oxygen, the absorption spectrum of the hæmochromogen is rapidly replaced by that of oxyhæmoglobin. These important observations were recently confirmed and extended by Haurowitz[2], who put forward the view that the formation of this anhydro-hæmoglobin is due to the removal of the water molecule occupying the sixth co-ordination bond of the iron atom, followed by polymerization of the resulting products, in which the iron of one is linked with the protein of another.

Haurowitz[3] also dried oxyhæmoglobin over phosphorus pentoxide in presence of sufficient air (*c.* 100 mm. mercury) to maintain the pigment in the oxygenated state. Once the anhydrous oxyhæmoglobin is formed, it cannot give up its oxygen in a high vacuum.

Since the iron both of hæmoglobin and oxyhæmoglobin is in the divalent state, it would appear interesting to determine the effect of drying upon methæmoglobin, the corresponding ferric compound.

The methæmoglobin used in these experiments was prepared by treating a strong solution of recrystallized horse oxyhæmoglobin in dilute sodium carbonate (pH $\sim$ 9) with ferricyanide and dialysing against water until completely free from ferricyanide. A brown solution of acid methæmoglobin (pH $\gtrsim$ 6) showing a distinct absorption band in the red region at about 630 mμ, when dried in a desiccator, gives a distinctly red product with two absorption bands, α 567, β 534 mμ, of which the β-band is much wider and stronger than the α-band. The red colour and the two-banded spectrum of the dry product are characteristic of a parahæmatin. On treating this dried product with water it rapidly dissolves, giving a clear brown solution with the absorption spectrum of acid methæmoglobin. On the other hand, fluoride methæmoglobin similarly dried retains its characteristic colour and absorption spectrum with its band at 605 mμ. The same applies to azide-methæmoglobin, except that here the phenomenon is more difficult to observe since the complex shows a certain spectroscopic resemblance to a parahæmatin. Cyan-methæmoglobin can also be dried unchanged under reduced pressure ($\frac{1}{2}$ atmosphere) over phosphorus pentoxide and dry potassium cyanide.

The experiments on drying hæmoglobin and methæmoglobin strongly support the view that the sixth bond in the octahedral complex of iron in these compounds is occupied by a molecule of water. In typical hæmochromogen and parahæmatin compounds, both the fifth and the sixth covalent bonds of iron are occupied by nitrogenous groups. It thus follows that on drying hæmoglobin or methæmoglobin the water molecule bound to their iron is replaced by a nitrogenous group in the protein either of the same or, as was suggested by Haurowitz[2], of another molecule of the pigment. In this connexion it is important to note that compounds in which the water molecule bound to iron is replaced by oxygen, as in the case of oxyhæmoglobin, or by fluoride, azide and cyanide ions, as in the case of the corresponding derivatives of methæmoglobin, show no change in their colour and absorption spectra when they are dried.

This study of the desiccation of methæmoglobin thus confirmed the results of our previous experiments on the effects of low temperatures on the absorption spectra of acid and alkaline methæmoglobin, where it was shown that the sixth position around iron in acid methæmoglobin is occupied by a molecule of water[4]. The formation of alkaline methæmoglobin therefore involves the loss of a proton[5] instead of the addition of a hydroxyl ion.

Although we have been able to confirm Haurowitz's conclusion that the dehydrated form of oxyhæmoglobin does not give up its oxygen in a high vacuum, we find that this conclusion is not adequately established by the experiment recorded in his Fig. 3. In fact, the positions and the relative heights of the bands α and β in the curve representing "anhydrous oxyhæmoglobin" indicate that a considerable part of the oxyhæmoglobin had been oxidized to methæmoglobin which, on drying, was converted to globin parahæmatin. When dissolved in sodium carbonate solution, such dry material would yield a mixture of alkaline methæmoglobin and oxyhæmoglobin. That such a mixture was indeed obtained is strongly suggested by the relative heights of the bands in the second curve of the same Fig. 3. By working rapidly we have been able to obtain both the anhydrous oxyhæmoglobin and its solution in carbonate showing the absorption spectrum of pure oxyhæmoglobin. There is therefore no doubt as to the correctness of Haurowitz's conclusion, notwithstanding the experimental results that he has given.

The reversible appearance of a hæmochromogen or a parahæmatin absorption spectrum during the drying of hæmoglobin or methæmoglobin respectively indicates that the drying process is accompanied by some reactions not unlike the reversible denaturation observed for the first time by Anson and Mirsky[6] on hæmoglobin treated with acid or salicylate. Moreover, it is well known that hæmoglobin is much less resistant to denaturation by alkali and acid than is oxyhæmoglobin. A similar difference between

methæmoglobin and oxyhæmoglobin can be demonstrated simply by shaking these solutions with chloroform, when only the former is denatured and is precipitated. When the water molecule bound to iron in methæmoglobin is replaced by fluoride or azide ions, however, the pigment acquires resistance to chloroform treatment. These results are exactly parallel to those observed in the desiccation experiments, which demonstrated an increased resistance of hæmoglobin and methæmoglobin to denaturation when their iron-bound water molecules are replaced by oxygen, fluoride or azide.

The reactions taking place during the drying of hæmoglobin and methæmoglobin, although perfectly reversible, appear to be of a more complex nature than the simple polymerization envisaged by Haurowitz[2], and to involve reversible changes in the architecture of the whole hæmoprotein molecule.

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Transaminases for Pyridoxamine and Purines

Braunstein's[1] demonstration of the transaminase reaction as a mode of formation of amino-acids has been broadened recently to include a wide variety of transaminases in bacteria[2], animal tissues[3] and plants[4]. In the present communication, we wish to report the formation of compounds other than amino-acids by the transaminase reaction.

Vacuum-dried cells of *Escherichia coli*, strains *B* and Crooks's, were used as sources of enzyme. Extracts were prepared by grinding cells with an equal weight of 500-mesh 'Carborundum', the cell debris removed by centrifugation and the clear, cell-free supernatant used directly, or after fractionation by precipitation with ammonium sulphate, followed by protamine treatment.

Table 1. Transaminases for Pyridoxamine, Adenine, Guanine and Cytosine

Reaction volume, 1 ml., containing:

M Phosphate buffer, *p*H 8·3	0·1 ml.
Alpha ketoglutarate	25 μM
Amino-donor	25 μM
Pyridoxal phosphate, calcium salt	10 γ
Cell extract	approx. 15 mgm. cells

Incubated 60 min., 37° C. Reaction stopped with 0·1 ml. 100 per cent trichloroacetic acid, 0·02 ml. transferred to paper and chromatogram developed with phenol/water (80/20). The μM glutamic acid (R_F = 0·36) formed per ml. were estimated from the chromatograms by comparison with the size and density of spots shown by known amounts of glutamic acid

Enzyme and substrate	μM Glutamate formed/ml. from amino-donors				
	No addition	Pyridoxamine	Adenine	Guanine	Cytosine
Extract	0·5	0·5	0·5	0·5	0·5
Extract, α-ketoglutarate	0·5	8	6	6	6
Extract, α-ketoglutarate, pyridoxal phosphate	0·5	8	6	6	6

The occurrence of a series of transaminases in these cell extracts is indicated by the results shown in Table 1. These preparations catalyse glutamate formation from alpha ketoglutarate in the presence of pyridoxamine, adenine, guanine and cytosine as amino-donors. The presence of ammonia does not lead to glutamate formation, thus indicating a transamination reaction. As shown in Table 2, the transfer of the amino-group of pyridoxamine to alpha ketoglutarate is dependent on the presence of the 'transaminase', pyridoxamine, alpha ketoglutarate and pyridoxal phosphate. The reversal of this reaction has been shown to occur with glutamic acid as amino-donor and pyridoxal as amino-acceptor.

Table 2. Pyridoxal Phosphate Requirement of Pyridoxamine Transaminase

Reaction volume, 1 ml. All samples contained 0·1 ml. *M* phosphate buffer, *p*H 8·3, enzyme, and additions as indicated. Substrate and coenzyme concentrations as in Table 1

Additions	μM Glutamate formed/ml.		
	Dried cells, 15 mgm.	Cell-free extract, approx. 15 mgm. dried cells	0·23–0·3 saturated ammon. sulphate fraction, approx. 15 mgm. dried cells
None	2	0·5	0
α-Ketoglutarate	2	2	0
α-Ketoglutarate, pyridoxamine	8	6	0
α-Ketoglutarate, pyridoxamine, pyridoxal phosphate	8	8	8

These observations suggest a mechanism of formation and interconversion of the purines and pyrimidines, and a route from pyridoxamine to pyridoxal. The importance of the transaminase reaction as a general mechanism of amino-transfer in living organisms is suggested.

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Formation and Breakdown of Pentose Phosphates by Liver Fractions

It has previously been shown in this laboratory[1] that at least two liver factors are necessary for the oxidation of D-ribose-5-phosphate by ammonium sulphate precipitated fractions of horse or rat liver, one being an aldolase and the other a dehydrogenase specific for coenzyme II. Ribose-5-phosphate is oxidized most rapidly by a combination of liver fractions *A* (0·4–0·5 saturation with ammonium sulphate) and *B* (0·5–0·6 saturation), the former being richest in glucose-6-phosphate dehydrogenase and the latter most active in splitting ribose-5-phosphate, as judged by the disappearance of pentose using the orcinol method[2]. The breakdown of ribose-5-phosphate, unlike the oxidation, is independent of coenzyme II and oxygen and never proceeds beyond 66–72 per cent disappearance of pentose.

Ketopentose phosphate formation has been detected by the cysteine–carbazole[3] and orcinol

methods, both during the oxidative decarboxylation of 6-phosphogluconate by liver fraction *C* (0·6–0·7 saturation) and during the splitting of ribose-5-phosphate by fraction *B*. This is in accord with Horecker and Smyrniotis[4], who found that a purified 6-phosphogluconic acid dehydrogenase from yeast first decarboxylated 6-phosphogluconate to ribulose-5-phosphate before conversion into ribose-5-phosphate. It would thus now appear that at least three liver factors are necessary for the oxidation of ribose-5-phosphate, namely, a pentose phosphate isomerase, an aldolase and a dehydrogenase specific for coenzyme II. It is of interest in this connexion that crystalline muscle aldolase does not split ribose-5-phosphate.

On attempting to synthesize ketopentose phosphate from triosephosphate and glycolaldehyde, the same ketopentose-1-phosphate was readily formed both with crystalline muscle aldolase and liver fraction *B*. This presumably is identical with the ketopentose-1-phosphate synthesized by Racker[5] with muscle aldolase and more recently by Hough and Jones[6] with pea aldolase, the latter workers identifying the ketopentose as xylulose. It is oxidized slowly by combined liver fractions *A* and *B*, the oxidation in the absence of coenzyme II, presumably due to oxidation of glycolaldehyde, being approximately half the rate of the oxidation in the presence of coenzyme II. The ketopentose-1-phosphate is relatively acid-labile, the hydrolysis constant in *N* hydrochloric acid at 100° being 86×10^{-3}, in comparison with $2{\cdot}5 \times 10^{-3}$ for synthetic ribose-5-phosphate.

Although glycolaldehyde is generally assumed to be the C_2 fragment resulting from enzymic breakdown of ribose-5-phosphate, experiments with liver fractions do not support this view. Glycolaldehyde has never been detected during the breakdown of ribose-5-phosphate by liver fraction *B* even under anaerobic conditions, and does not disappear on incubating with this liver fraction, although it is slowly oxidized, in the absence of coenzyme I or II, by combined $A + B + C$ liver fractions. Moreover, although normally the breakdown products of ribose-5-phosphate are rapidly converted into hexosemonophosphate, in the presence of glycolaldehyde no hexosemonophosphate is formed but instead the same ketopentose-1-phosphate accumulates as is synthesized from triosephosphate and glycolaldehyde.

Most of the ribose-5-phosphate broken down by liver fractions has been accounted for by hexosemonophosphate formation, which has previously been shown to be formed from ribose-5-phosphate by liver[7] and hæmolysed erythrocytes[8]. Hexosemonophosphate has been determined by measuring the oxygen uptake on addition of coenzyme II and liver fraction *A* (rich in glucose-6-phosphate dehydrogenase but completely inactive in oxidizing ribose-5-phosphate and glycolaldehyde) to heat-inactivated ribose-5-phosphate digests by liver fraction *B*, and also by measuring the rate of reduction of coenzyme II at 340 mμ either on addition of liver fraction *A* or of a purified *Zwischenferment*[9]. At least 75 per cent of the ribose-5-phosphate broken down is converted into hexosemonophosphate, fructosemonophosphate being formed first and gradually converted into glucose-6-phosphate. This is much greater than the 50 per cent conversion which could occur by aldolase condensation of the triosephosphate formed from ribose-5-phosphate, and indicates that the rest of the pentose molecule must be incorporated. Synthesis of hexosemonophosphate does not proceed via fructose-diphosphate, since these liver fractions are devoid of fructosediphosphatase and, moreover, fructose-diphosphate is not oxidized at all even by combined $A + B + C$ liver fractions, which actively oxidize fructose-6-phosphate, glucose-6-phosphate and ribose-5-phosphate.

This work will be published in detail elsewhere.

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Glucuronide Decomposition in the Digestive Tract

THE discovery of an enzyme decomposing glucuronide in the rumen of the sheep[1] has been followed by the detection of similar enzymes in the large intestine of the horse[2] and in locust crop liquor[3]. It seemed possible that such enzymes are concerned in the digestion of polysaccharides containing β-linked glucuronic acid residues, such as hemicellulose and hyaluronic acid, and a survey was therefore made of their occurrence in different parts of the alimentary tract in various species of animal. Typical results are shown in the accompanying table. It should be pointed out that these results are only of qualitative value, since the enzyme assays were carried out under conditions which are optimal for the sheep rumen enzyme[1], but are not necessarily so for the enzymes from other sources. Moreover, in the rumen, omasum, cæcum and colon, the enzymes may well be of microbial origin, as has been shown for the sheep rumen enzyme[1], and therefore surrounded by membranes of varying toughness and permeability. A further factor which was not controlled was the diet of the animals, some of the material being obtained from the slaughter-house.

In spite of the reservations made above, the results in the table are of considerable interest in showing the occurrence of very active enzymes of this type in the digestive tracts of all species of animal studied. So far as any generalizations are possible, it may be said that enzyme activity was appreciable in the fore-stomachs of ruminants, and very high in the large bowel of all species. Activity was low or lacking in the stomach, abomasum or gizzard. Appreciable activity was frequently noted in the small intestine. This may have been due to secretion of animal tissue β-glucuronidase into the lumen or to sloughing of epithelial cells.

Enzymes from many sources were tested for inhibition by 0·00025 *M* saccharo-1 : 4-lactone. In this concentration, the lactone causes complete inhibition of mouse liver β-glucuronidase, but only 50 per cent inhibition of the enzyme from the rumen of the sheep[4]. In the present experiments it caused

Distribution of Enzymes Decomposing Glucuronide in the Alimentary Tract
μgm. Phenolphthalein liberated in 1 hr. at 37° and *p*H 6·1 (phosphate buffer) from 0·0005 *M* phenolphthalein glucuronide by 1 ml. strained gut content)

Animal	Rumen	Omasum	Stomach or abomasum	Duodenum	Ileum	Cæcum	Colon (proximal)	Colon (distal)
Sheep	112	161	0	174	143	3,880	2,700	3,425
Cow	31	166	37	82	65	1,168	154	1,292
Horse	—	—	0	not done	2	107	515	229
Rabbit	—	—	0	19	9	3,000	2,100	
Rat	—	—	0	114	127	4,300	2,800	
Pig	—	—	20	0	45	968	1,020	189
Cat	— Crop	— Gizzard	0	126	116	392	331	
Fowl	46	0	empty	221	363	8,080	189	

complete inhibition of the enzyme in the duodenum and 35–64 per cent inhibition of the enzyme in the rumen or large intestine.

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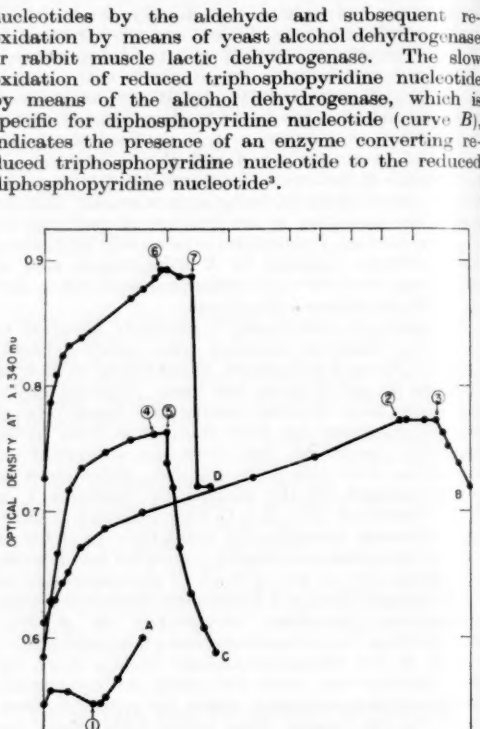
Triosephosphate Dehydrogenase and Glucose-6-Phosphate Dehydrogenase in the Pea Plant

There is considerable evidence indicating that the mechanisms of carbohydrate catabolism are the same in higher plants, yeast and muscle[1]. However, it has been reported that mature pea plants do not oxidize triosephosphate[2].

We find that extracts of roots, stems and leaves of pea plants, 16 and 22 days old, prepared by treatment of the tissues with 0·1 *M* disodium hydrogen phosphate and ammonium sulphate fractionation, contain enzymes catalysing the oxidation of glyceraldehyde-3-phosphate by the pyridine nucleotides. There appears to be two enzymes in stem and leaf, one requiring triphosphopyridine nucleotide, the other diphosphopyridine nucleotide. The enzyme of the root is active only with the latter nucleotide.

Oxidation of the triosephosphate with diphosphopyridine nucleotide does not occur until the extracts are incubated with cysteine even when freshly prepared. Oxidation with triphosphopyridine nucleotide occurs in extracts without cysteine. Both enzymes are inhibited by iodoacetamide, but that requiring triphosphopyridine nucleotide appears less sensitive. The accompanying graph illustrates the activity of the triosephosphate dehydrogenases as indicated by reduction of the nucleotides by glyceraldehyde-3-phosphate. Reactions were run in Beckman quartz cuvettes (d = 1 cm.) with a total volume of 3·0 ml., and readings were made against a water blank. All reaction mixtures contained veronal buffer, *p*H 8·0, 52 μ*M* sodium arsenate, 60 μ*M* sodium fluoride. Curve *A* indicates the effect of cysteine on the enzyme requiring diphosphopyridine nucleotide. Curves *B*–*D* indicate reduction of the nucleotides by the aldehyde and subsequent reoxidation by means of yeast alcohol dehydrogenase or rabbit muscle lactic dehydrogenase. The slow oxidation of reduced triphosphopyridine nucleotide by means of the alcohol dehydrogenase, which is specific for diphosphopyridine nucleotide (curve *B*), indicates the presence of an enzyme converting reduced triphosphopyridine nucleotide to the reduced diphosphopyridine nucleotide[3].



Curve *A*. Effect of cysteine on activity of coenzyme I linked triosephosphate dehydrogenase. 1·5 μ*M* glyceraldehyde-3-phosphate, 0·03 ml. fresh leaf extract, 0·17 μ*M* diphosphopyridine nucleotide. At arrow 1, 12 μ*M* cysteine added.
Curve *B*. Reduction of triphosphopyridine nucleotide by leaf enzyme. 0·14 μ*M* triphosphopyridine nucleotide, 0·03 ml. of three-week old 40–50 per cent ammonium sulphate fraction of leaf extract. Reaction started by addition of 1·5 μ*M* glyceraldehyde-3-phosphate. At arrow 2, 50 μ*M* acetaldehyde added; at arrow 3, crystalline yeast alcohol dehydrogenase added.
Curve *C*. Reduction of triphosphopyridine nucleotide by leaf enzyme and reoxidation with lactic dehydrogenase. 0·14 μ*M* triphosphopyridine nucleotide, 0·03 ml. of same leaf fraction used in curve *B*, 12 μ*M* cysteine. Reaction started by addition of 1·5 μ*M* glyceraldehyde-3-phosphate. At arrow 4, 50 μ*M* sodium pyruvate added; at arrow 5, rabbit muscle lactic dehydrogenase added.
Curve *D*. Reduction of diphosphopyridine nucleotide by leaf enzyme and reoxidation by alcohol dehydrogenase. 0·17 μ*M* diphosphopyridine nucleotide, 0·03 ml. fresh leaf extract incubated 6 min. with 12 μ*M* cysteine. Reaction started with 1·5 μ*M* glyceraldehyde-3-phosphate. At arrow 6, 50 μ*M* acetaldehyde added; at arrow 7, crystalline yeast alcohol dehydrogenase added

The roots, stems and leaves also possess a glucose-6-phosphate dehydrogenase which is active only with triphosphopyridine nucleotide. This activity is not affected by iodoacetamide or fluoride but is increased by cyanide. Triphosphopyridine nucleotide reduced by the glucose-6-phosphate dehydrogenase can be re-oxidized by the extracts of the leaf and stem with 3-phosphoglycerate in the presence of adenosine triphosphate.

Since the triosephosphate dehydrogenase requiring triphosphopyridine nucleotide was found only in parts of the plant containing chlorophyll, it is of interest to speculate that it participates only in photosynthesis, that is, in the conversion of phosphoglycerate to triosephosphate, whereas the other dehydrogenase is concerned in carbohydrate catabolism. The presence of a glucose-6-phosphate dehydrogenase indicates that plant tissue may degrade hexose by a mechanism similar to that of yeast[4] or animal tissue[5].

Full details of this investigation, which was carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission, will be published elsewhere.

I am indebted to Prof. E. Baer for a generous gift of the dioxane addition compound of *dl*-glyceraldehyde 1-bromide 3-phosphoric acid. I am also indebted to Dr. Ralph DeMoss for many helpful suggestions.

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Glycerol as a Nutritive for *Vibrio choleræ*

IT has been found that glycerol, incorporated in a medium suitable for growing *Vibrio choleræ*, increases the number of organisms yielded. This effect of glycerol is strongly enhanced when phosphates are present as well. Glycerol, in a concentration of 2·2 per cent (corresponding to 1·5 ml. glycerol per 100 ml. medium), doubles the harvest obtained from a solid basal medium containing 1 per cent peptone and 0·5 per cent sodium chloride. Omitting the glycerol and adding phosphate (0·25 per cent disodium hydrogen phosphate) to the basal medium raises the crop only slightly.

A more than sevenfold yield, however, is due to the combined action of glycerol and phosphate in the concentrations stated above. This manifold improvement in growth is nearly the same for two different strains used in vaccine production, namely, Ogawa and Inaba.

It is intended to publish a fuller report of this work elsewhere.

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Lepine and Sautter's Disease in Great Britain

THE first guinea pig lung showing symptoms like that of the subclinical virus disease described by Lepine and Sautter[1] was found in Great Britain two years ago. Since that time, examination of guinea pigs from various sources has shown that this condition causing microscopical lung hepatization is widespread in Britain.

As in the cases of Lepine and Sautter, the animals exhibited no clinical symptoms. The only macroscopical change is that the lung is a lighter pink than usual; the hepatization of the lung can only be detected on microscopical examination, and is the sole means of identification.

Histopathological changes observed in the lung can be divided into two groups.

(1) *Peribronchial condensation in the lung.* This is characterized by proliferation and accumulation of a variety of cells, including fibroblasts, reticulocytes, developing cells of the lymphoid series, and a large number of small lymphocytes (see photograph). With reticulum staining, these areas show an abundance of reticular fibres.

Type I condensation (hæmatoxylin-eosin). × 100

(2) This type of condensation is characterized by a thickening of the alveolar wall due to cellular proliferation, involving particularly the capillary endothelium. No inclusion bodies could be detected in any of the condensations, either with neutral red (Duffet) or phloxyn-tartrazin (Lendrum) staining.

Since bacteriological examination was negative, it is logical to assume that the disease was caused by virus. I have been unable to determine whether this condition is identical with that described by Lepine and Sautter; nevertheless, the extent of distribution warrants a more extensive investigation.

My thanks are due to Mr. R. C. James for his technical assistance.

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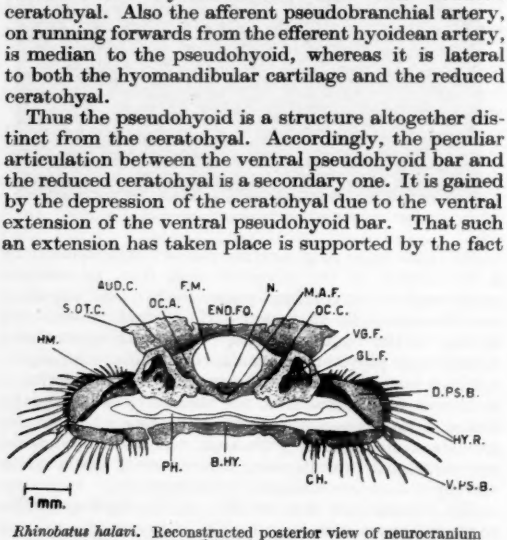
Hyoid Arch of Rhinobatidæ

The skeleton of the hyoid arch of Batoidei has been for many years the subject of discussion by morphologists. Gegenbaur[1] considered the hyoid elements bearing hyal rays and lying posterior to the hyomandibular cartilage to represent the ceratohyal of Selachoidei, which became disconnected from the ventral edge of the hyomandibular and extended upwards behind it. Krivetski[2] and de Beer[3] considered these hyoid elements as pseudohyoid and formed by the fusion of the proximal ends of the hyal rays. Such a phenomenon occurred during the phylogenetic divergence between Batoidei and Selachoidei, and was largely associated with the increased distance between the mouth and first gill slit in Batoidei. Thus the pseudohyoid elements were necessary for providing a support for the hyal rays, as well as the anterior wall of the first gill slit. During the enlargement and extension of these pseudohyoid elements, the original ceratohyal in Batoidei has disappeared.

The study of the hyoid arch of Rhinobatidæ, as represented by *Rhinobatus halavi* and *Rhynchobatus djiddensis* from the Red Sea, supports the view of both Krivetski and de Beer. As a matter of fact, both *Rhinobatus halavi* and *Rhynchobatus djiddensis* are transitional forms between Selachoidei and Batoidei (Bridge[4], Regan[5] and Goodrich[6]). It is found that in these two fishes the original ceratohyal, which has completely disappeared in specialized Batoidei, is still persisting in addition to the pseudohyoid. This ceratohyal, which is relatively much reduced, bears the correct relations of a selachoid ceratohyal to the afferent hyoidean artery, being immediately dorsal to it. Also it is still bearing hyal rays. The originally direct connexion between the hyomandibular and ceratohyal of Selachoidei can be traced by the presence of a ligamentous vestige between the hyomandibular and this reduced ceratohyal. Also the afferent pseudobranchial artery, on running forwards from the efferent hyoidean artery, is median to the pseudohyoid, whereas it is lateral to both the hyomandibular cartilage and the reduced ceratohyal.

Thus the pseudohyoid is a structure altogether distinct from the ceratohyal. Accordingly, the peculiar articulation between the ventral pseudohyoid bar and the reduced ceratohyal is a secondary one. It is gained by the depression of the ceratohyal due to the ventral extension of the ventral pseudohyoid bar. That such an extension has taken place is supported by the fact that the more ventral hyal rays are loosely attached to the ventral pseudohyoid bar while the dorsal rays are completely fused with it. It is to be noted also that the amount of depression of the ceratohyal in *Rhinobatus halavi* is relatively greater than that in *Rhynchobatus djiddensis*. This shows that these transitional forms represent different steps towards the highly specialized Batoidei, where the ceratohyal is completely missing. The condition of *Rhinobatus halavi*, possessing a smaller ceratohyal, seems to be somewhat beyond that of *Rhynchobatus djiddensis* towards the more specialized Batoidei. This agrees with the conclusion arrived at by Melouk[7] from embryological considerations.



Rhinobatus halavi. Reconstructed posterior view of neurocranium and hyoid arch.
AUD.C., auditory capsule; *B.HY.*, basihyal; *CH.*, ceratohyal; *D.PS.B.*, dorsal pseudohyoid bar; *END.FO.*, endolymphatic fossa; *F.M.*, foramen magnum; *GL.F.*, glossopharyngeal foramen; *HM.*, hyomandibular cartilage; *HY.R.*, hyal rays; *M.A.F.*, median articular facet for anterior vertebral plate; *N.*, notochord; *OC.A.*, occipital arch; *OC.C.*, occipital condyle; *PH.*, pharynx; *S.OT.C.*, supraotic crest; *V.PS.B.*, ventral pseudohyoid bar; *VG.F.*, vagus foramen

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Epidermal Glands in Centipedes

The epidermis of a centipede is virtually an epithelium of unicellular glands, their secretion being extruded over the surface of the cuticle[1]. In addition to the general epidermal glands, there are local groups of much larger glands histologically similar to the generally distributed glands. Their secretions are chemically similar and, furthermore, they have similar properties to the sclerotin and pro-sclerotin[1] of the cuticle.

Opening on the sternites of Geophilomorphs are batteries of large columnar gland cells. The secretion from these sternal glands in *Haplophilus subterraneus* is a white mobile fluid when extruded, but it rapidly hardens into an amber-coloured material on exposure to the air. Attems[2] has described a similar secretion from the sternal glands of *Himantarium gabrielis*. Similar batteries of glands are found in Lithobiomorphs, though they do not appear to have been described. They open by numerous pores on the inner, morphologically posterior face of the four distal podomeres (femur, tibia, tarsus and metatarsus) of the last two pairs of legs. They may be referred to as the 'telopodal glands'. Like that of the sternal glands their secretion hardens on exposure, forming a material which is amber-coloured when seen in mass, but is normally extruded as long sticky fibres resembling silk. This secretion has been noted by Verhoeff[3] and Willem[4], although they both state incorrectly that the material is extruded from the coxal glands ('glandes filières' of Willem).

Telopodal glands have been examined in several species of *Lithobius* and in the related genus *Lamyctes*. Like the general epidermal gland secretions[1], that of the sternal and telopodal glands colours with sudan black. It is intensely positive to Millon's reagent and also gives a positive ninhydrin test. The secretion thus appears to be a lipoid-protein complex or mixture. It is very similar in this respect to the sclerotin and pro-sclerotin of the cuticle, in which phenolic groups, probably tyrosine residues, are

likewise abundant[1]. The resemblance of the secretion to silk recalls Trim's comparison of the protein-chitin complex of the insect cuticle with silk[5]. It has been suggested that the lipoid material from the general epidermal gland cells of centipedes, having been extruded over the surface of the cuticle, undergoes some change which renders its outer surface hard and inert[1]. Since the secretion from the sternal and telopodal glands appears to be a similar substance and possesses the property of spontaneous hardening, this suggestion may receive further support. A similar relation between the general and special tegumental gland secretion and the outer layers of the cuticle has been demonstrated in certain Crustacea[6,7].

It is hoped to publish a full account of these specialized glands in centipedes, together with notes as to their possible function, in the near future.

GORDON BLOWER

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Feb. 5.

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'Infra-Red' Brooding and the Crooked-Toe Problem in Chicks

LAST season, following the reports that rearing under the bright emitter type of 'infra-red' lamp caused an increased incidence in chicks of a crooked-toe deformity, we reared several hundred chicks from our own stock on solid floors so that we could study the problem at first hand. Despite the fact that we did everything possible to induce the condition, for example, varying the height of the lamp above the chicks, damping the litter, and using various diets, we failed to produce a single case of crooked toe.

Towards the end of the season, with the co-operation of the National Agricultural Advisory Service, we were able to obtain some growing birds from an outside source, which had been reared under 'infra-red' and which showed the deformity. Although these birds were obtained primarily for X-ray examination, they were reared to maturity and bred from for experimental purposes.

Chicks, apparently normal on hatching, from the crooked-toed parents have been reared along with some of our own chicks under the same 'infra-red' lamp, and whereas 100 per cent of the progeny from the crooked-toed parents have developed the deformity, our own chicks have remained quite normal. When second batches of chicks from both sources were reared together, using ordinary electrical heating, neither the progeny from the crooked-toed parents nor our own stock developed the malformation.

It would therefore appear that this particular type of crooked toe is of a hereditary nature, the susceptibility being inherited by some strains whereas others are resistant. The indication is that the manifestation of this type of crooked toe appears in susceptible strains of chicks under the particular environmental conditions provided, possibly by the combination of bright emitter 'infra-red' lamps—or perhaps prolonged exposure to artificial light—with rearing on solid floors.

If this is the case, then it would appear that certain non-susceptible strains of chicks can be reared successfully under luminous 'infra-red' lamps without the risk of crooked toe deformity appearing: and starting with a 'susceptible' strain it should be possible, by selection, to breed for resistance to the development of crooked toes under 'infra-red' rearing.

While cases of crooked toe in chicks have been previously reported, this hereditary relationship to 'infra-red' brooding has not hitherto, so far as we are aware, been described.

D. J. G. BLACK
J. GETTY
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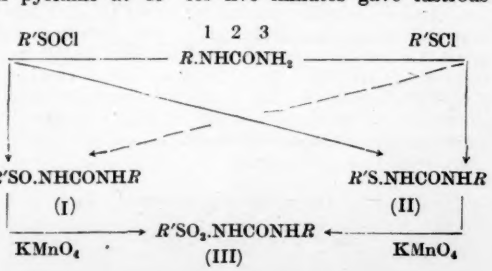
Feb. 7.

Sulphinylureas and Sulphenylureas

THE interaction of aromatic ureas with carboxylic acid chlorides in pyridine solution under restrained conditions yields N-carbonyl-N′-arylureas[1]. The corresponding reaction with sulphonyl chlorides, however, occurs with simultaneous dehydration and formation of N-arylsulphonyl-N-arylcyanamides[2]. In continuation of the latter work, the action between aromatic ureas and sulphinyl chlorides has been studied. The results obtained necessitated the examination of the corresponding reaction involving sulphenyl chlorides.

Unlike sulphonyl halides, which appear to attack the substituted urea molecule at the oxygen atom (2), forming unstable intermediate O-sulphonylureas [*R*NH.C(: NH).OSO$_2$*R*′] [2,3], sulphinyl chlorides substitute at the nitrogen (3), yielding N-arylsulphinyl-N′-arylureas (I) as one of the main products. Considerable quantities of N-arylsulphenyl-N′-arylureas (II), presumably formed by an oxidation-reduction mechanism operating during the reaction, are also isolated. Both products of the reaction are oxidized by alkaline permanganate to sulphonylureas of known formula (III); this observation establishes the structures of the sulphinyl- (I) and sulphenyl-ureas (II); hydrolytic fission of the compounds under various conditions provides further evidence in support of the suggested formulæ. Finally, N-arylsulphenyl-N′-arylureas are found to be almost the exclusive products of the interaction of arylureas and sulphenyl halides.

Thus, for example, the interaction of phenylurea (1 mole) and toluene-*p*-sulphinyl chloride (2·5 moles) in pyridine at 45° for five minutes gave lustrous



plates of N-phenyl-N′-toluene-*p*-sulphinylurea (melting point 164°, decomp.) and opaque needles of N-phenyl-N′-toluene-*p*-sulphenylurea (melting point 172°, decomp.) (each in 25–35 per cent yields), together with smaller quantities of *p*-tolyl toluene-*p*-thiolsulphonate and di-*p*-tolyldisulphide. The analogous reaction with toluene-*p*-sulphenyl chloride gave the sulphenylurea and sulphinylurea in 65 and 3 per cent yields respectively. Similar results were obtained with other members of the urea series.

In their reactions with arylureas, sulphinyl and sulphenyl chlorides thus resemble halides of carboxylic acids rather than those of sulphonic acids. Further experiments in connexion with this work, particularly its extension to the thiourea-series, are in progress, and a detailed account will appear elsewhere in due course.

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Feb. 9.

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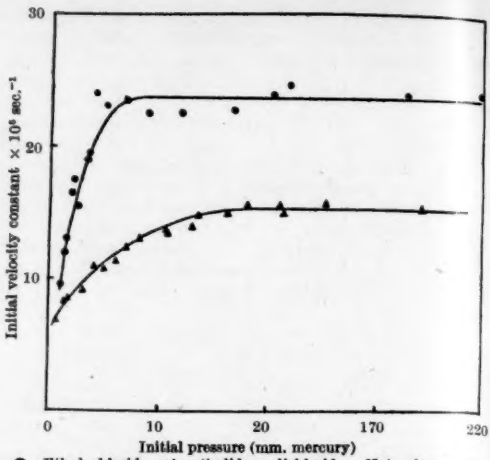
Unimolecular Chlorohydrocarbon Decompositions

Theories of gaseous unimolecular reactions have often been discussed[1]; but very few examples of processes occurring virtually completely by this mechanism have been used to compare theory and experiment. Thus the decompositions of azomethane, nitrous oxide and nitrogen pentoxide, which have been exhaustively examined from this point of view, are not now considered to be simple unimolecular reactions[2]. It is desirable, therefore, to have authenticated examples, and some evidence has already been presented that the homogeneous, first-order pyrolyses of ethyl, *iso*propyl and *tert.* butyl chlorides and of ethylidene dichloride are of this type[3]. This evidence is found mainly in comparisons with the obvious radical chain-decompositions of 1.2 dichloroethane and the tetrachloroethanes[4]. In contrast with the latter, the former show no induction periods, no inhibition by propylene, little sensitivity to oxygen and chlorine, and, in the case of ethyl chloride, there is reasonable agreement between the experimental activation energy and that calculated by the semi-empirical method.

These apparently unimolecular processes are now being examined at low pressures in an apparatus essentially similar to that used previously[3,4]. The rate-constants for the decompositions of ethyl chloride and ethylidene dichloride have been shown to fall from the high-pressure values less than $p = 6$ mm. of mercury at 456° C. and 17 mm. at 412° C. respectively. The accompanying graph illustrates the results obtained. It may be noted that at high pressures the reported rate-constants agree satisfactorily with those calculated from the rate-equations given by Barton and Howlett[3].

The classical theory of unimolecular reactions:

$$k = \frac{A\{\exp(-E/RT)\}\,(E/RT)^{s-1}}{(s-1)\,!}$$



●, Ethyl chloride; ▲, ethylidene dichloride. Note change of scale above 20 mm.

may be used in conjunction with the inflexion point in the curve of rate-constant against pressure to estimate the number of vibrational degrees of freedom (s) contributing towards the activation energy[5]. By assuming collision diameters of 6 A. in each case[6], the values of s are calculated to be 15 for ethyl chloride and 7 for ethylidene dichloride.

The order of reaction for ethylidene dichloride pyrolysis begins to rise perceptibly above unity at pressures less than 4 mm. mercury and reaches approximately 1·5 at 1 mm. pressure. Thus the evidence that these reactions are truly unimolecular is considerable. Further work is in hand and will be fully reported shortly.

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Feb. 10.

[1] Compare, for example, *Chem. Rev.*, **10**, 1 (1932), symposium on the kinetics of homogeneous reactions. Kassel, L. S., "Kinetics of Homogeneous Gas Reactions" (Chem. Catalogue Co., 1932). Hinshelwood, C. N., "Kinetics of Chemical Change" (Oxf. Univ. Press, 1940). Glasstone, S., Laidler, K. J., and Eyring, H., "Theory of Rate Processes" (McGraw-Hill, 1941).
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[5] Compare Hinshelwood, C. N., *loc. cit.*, p. 81.
[6] Computed from the viscosity data for ethane, by analogy with the variation in the chloromethanes; see Partington, J. R., "Advanced Treatise on Physical Chemistry", 860 (Longmans, 1949).

Chlorogenic Acids in Fruit Trees

Work on the chemical composition of the various parts of fruit trees, particularly apple and pear, is proceeding at Long Ashton and East Malling Research Stations and the Ditton Laboratory. The problems being studied are not quite the same in each laboratory, but discussions of common interests have disclosed certain overlapping findings. For this

reason, we wish jointly to report the presence of chlorogenic acid in both mature and immature apple and pear fruits, and of this substance and a substance similar to, or identical with, *iso*chlorogenic acid of coffee[1] in leaves and shoots of pear.

Details of the work will be given in independent publications elsewhere.

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Food Investigation Organization,
Department of Scientific and
Industrial Research,
East Malling, Kent.

A. H. Williams
Long Ashton Research Station,
University of Bristol.

[1] Barnes, Feldman and White, *J. Amer. Chem. Soc.*, **72**, 4178 (1950).

The Symmetrical Spherical Top

The plastic toy top described by C. M. Braams[1] recalls a similar top described in some detail in Prof. John Perry's "Operatives' Lecture of the British Association Meeting at Leeds, September 6, 1890", or in his book "Spinning Tops", 67–74 (Society for Promoting Christian Knowledge, 1890). He gives the reason for the unusual behaviour of the top in terms of the rule: "Hurry on the precession and the body rises in opposition to gravity", and ascribes the theory of the effect to Lord Kelvin (1874). Perry's Fig. 35, which is on p. 75 of "Spinning Tops", is almost the modern "Tippe Top".

G. N. Copley
17 Calderstones Avenue,
Liverpool, 18.

[1] *Nature*, **170**, 31 (1952).

"Library Services in the British Colonial Territories"

The thoughtful and well-informed article on this subject in *Nature* of May 24 will be keenly appreciated by all who also regard the establishment of adequate public library services in these territories as a matter of high priority, being a prerequisite of both economic and social development. The Library Association, with the full co-operation of the Colonial Office, has recently appointed a Committee to advise on all aspects of library provision in the Colonies.

The Library Association warmly supports the contention that "There is clearly a need for a body with driving force capable of providing the finance to establish public libraries and the ability to organize and direct their development until the local governments are able to take over" the responsibility.

Nevertheless, there are difficulties which it would be wrong to under-estimate. First, it is a basic constitutional principle that the Metropolitan Government does not direct Colonial development, or indeed interfere any more than is necessary in local affairs. Thus it is not possible for the British Government to impose any pattern or standards; it can only encourage and guide. Consequently its functions, however implemented, must be limited to initiating and financially aiding pilot or demonstration projects, assisting in schemes for professional education, and affording advice, bibliographical services and the like. Some of this help must be on a short-term basis, preferably diminishing as local support increases. But it is cardinal that initial help should not be withdrawn until the local support is sufficient, otherwise all that has been achieved is thrown away. Yet that is what is in danger of happening, for example, in the Eastern Caribbean. Moreover, all these pilot schemes must enjoy a measure of security, as otherwise planning is impossible, and those who undergo training for librarianship must be assured that they will have permanent scope and employment.

The second great difficulty is that no sound library services can be started or maintained without properly selected, trained and experienced staff. It is, therefore, though obviously unintentionally, misleading to suggest that "the cost of establishing adequate library systems throughout the British Colonial Empire would be very small, and no more than a small team of librarians working in the field would be required". The idea of such a team starting one scheme in one Colony and then moving on to another and so on may seem attractive but is actually impracticable. Each scheme needs two or three first-class, thoroughly experienced leaders capable of starting the job and seeing it through, and of building up well recruited and trained local staff to maintain the services permanently, a task which will occupy a great part of their professional lifetime. We must avoid thinking of library services as inexpensive undertakings. Good libraries must be expensive, which does not prevent their being worth while; on the contrary, the inexpensive are the least worth while. It is absurd to imagine that nation-wide public libraries can, in a year or two and at small cost, be established in the towns and throughout the country districts of a multi-lingual, multi-culture Colony with scarcely any vernacular literature, which will be adequate for the needs of those who can read and those who will be able to read as fundamental education projects begin to achieve full results.

If it is reasonable to argue that any particular Colonial Government cannot afford to maintain adequate libraries, then the case for aid from the British Government is all the stronger. For one thing is absolutely sure: that without education, and the libraries that are the essential accompaniment of educational development, these people will never be able to afford libraries, or anything else beyond bare subsistence. Without adequate library services, the British Colonial territories will never be able to achieve proper standards of living for their peoples, and the ideal of democratic self-government will either remain a dream or prove a tragic failure. Therefore, we would urge all who have a sense of responsibility in this matter to support the Colonial authorities in their educational and library development policies and to urge that the British Council, in co-operation with the Colonial Office, be enabled to resume its library work in these territories, and to resume it with much greater resources than were ever enjoyed before.

Lionel R. McColvin
(President)
The Library Association,
Chaucer House, Malet Place,
London, W.C.1.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

ASSISTANT LECTURERS (Grade B) IN THE DEPARTMENT OF CHEMISTRY AND APPLIED CHEMISTRY—The Principal, Royal Technical College, Salford (August 2).

BACTERIOLOGIST (with good honours degree and research experience), for work concerned with aspects of the microbiology of the gut flora of the bovine, the pig and the chick used as experimental animals —The Secretary, National Institute for Research in Dairying, Shinfield, Reading (August 2).

SUPERVISING GEOLOGIST in the Geological Section of the Department of National Development, Canberra, to be responsible for the supervision of field operations of the Sedimentary Basins Subsection, including geological mapping and assessment of petroleum possibilities of sedimentary basins in Australia, and to prepare reports relating to the occurrence of oil in Australia—The Deputy High Commissioner, Australia House, Strand, London, W.C.2, endorsed 'For the attention of the Senior Representative, Division of Industrial Development' (August 7).

ASSISTANT (with an honours degree in bacteriology, or its equivalent) TO THE ADVISORY BACTERIOLOGIST—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (August 9).

DEMONSTRATOR (with an honours degree in chemistry or biochemistry) IN THE DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (August 9).

SCIENTIST, Grade II (with a good university honours degree, or equivalent, in chemistry or physics, chemical engineering, or fuel technology) on the staff of the Director of Scientific Control at London headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/500 (August 9).

SOIL CONSERVATION OFFICERS (with a degree in conservation, agriculture, agricultural engineering or pure science)—The Secretary, Southern Rhodesia Government, 429 Strand, London, W.C.2 (August 10).

ASSISTANT PHYSICIST to work on medical applications of radioactive isotopes—The House Governor and Secretary, Royal Cancer Hospital, Fulham Road, London, S.W.3 (August 11).

ASSISTANT LECTURER IN PSYCHOLOGY—The Registrar, University College, Hull (August 12).

DIRECTOR (qualified in archæology or natural history, with experience of the organization of art exhibitions) OF THE ART GALLERY AND MUSEUM—The Town Clerk, Town Hall, Doncaster (August 14).

AGRICULTURAL ECONOMIST, and ASSISTANT AGRICULTURAL ECONOMISTS—The Registrar, The University, Manchester 13 (August 15).

LECTURER IN CHEMISTRY, and a LECTURER IN THE DEPARTMENT OF MINING AND GEOLOGY—The Principal, Wigan and District Mining and Technical College, Wigan (August 15).

RESEARCH OFFICER (with university honours degree, or equivalent qualification) to undertake some fundamental studies into the colloidal properties of a flour-water dough, at the School of Applied Chemistry, N.S.W. University of Technology, Sydney—The Director, Bread Research Institute of Australia, 111 Pacific Highway, North Sydney, Australia (August 15).

ASSISTANT LECTURER IN BACTERIOLOGY—The Registrar, The University, Manchester 13 (August 18).

SENIOR TECHNICAL OFFICER IN THE COAL RESEARCH SECTION, Delhi Road, North Ryde, Australia, to assist in a survey of the physical and chemical properties of Australian coals, with special emphasis on the supervision of staff engaged ou the selection and preparation of samples—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2 (August 23).

LEADER (with a first- or second-class honours degree in physics or metallurgy, or an equivalent qualification, with at least three years postgraduate research experience) OF THE METAL PHYSICS GROUP of the Metallurgy Department, Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.196/52A (August 29).

LECTURER IN MATHEMATICS at University College, Dundee—The Secretary, The University, St. Andrews (September 1).

LECTURER IN PHYSICS at New England University College (University of Sydney), Armidale, N.S.W.—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 1).

LECTURER IN PLANT PHYSIOLOGY IN THE DEPARTMENT OF BOTANY, Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 8).

LECTURER IN EXPERIMENTAL PHARMACOLOGY—The Secretary of University Court, The University, Glasgow, W.2 (December 31).

AGRICULTURAL CHEMIST—The Director, Tea Research Institute of Ceylon, Talawakelle, Ceylon.

ASSISTANT (Grade A) to teach MATHEMATICS up to Degree standard —The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex.

ASSISTANT LECTURER (Grade B) IN THE PHYSICS DEPARTMENT—The Clerk, Northern Polytechnic, Holloway, London, N.7.

ASSISTANT LECTURER IN THE PHYSIOLOGY DEPARTMENT—The Warden and Secretary, Royal Free Hospital School of Medicine, Hunter Street, London, W.C.1.

CHEMIST, to study the degradation of leather in wear, and other related problems—The Director, British Boot, Shoe and Allied Trades Research Association, Satra House, Rockingham Road, Kettering, Northants.

CHEMIST/ASSAYER in Northern Rhodesia, to carry out assays and analyses of ores, minerals and rocks in the laboratory of the Geological Survey Department—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27106/57/52.

ENGINEER in the Ministry of Supply near Sevenoaks, to engineer electronic and radar equipment for flying trials—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.299/52A.

ENGINEER with wide experience in the application of electronic and servo-mechanical methods to the control of operations—The Printing, Packaging and Allied Trades Research Association, Patra House, Randalls Road, Leatherhead, Surrey.

EXPERIMENTAL ASSISTANT (with a knowledge of chemistry and physics up to degree standard) for research on chalk products—The Director of Research, Research Council of the British Whiting Federation, 245 Ampthill Road, Bedford.

GRADUATE ASSISTANT BIOCHEMIST (experience in hospital biochemistry and a higher degree in chemistry or biochemistry are essential)—The Medical Superintendent Western General Hospital, Edinburgh.

HEAD OF THE DEPARTMENT, and a PLANT BREEDER, in the Department of Hop Research—The Registrar, Wye College, Wye, Ashford, Kent.

HEAD OF THE DEPARTMENT OF POWER ENGINEERING AND ELECTRICAL TECHNOLOGY in the Indian Institute of Science, Bangalore —The Ministry of Labour and National Service (A.S.12), Almack House, 26 King Street, London, S.W.1, quoting A.12/1.30E.

LECTURER IN PHYSIOLOGY—The Secretary, Charing Cross Hospital Medical School, 62 Chandos Place, London, W.C.2.

MECHANICAL AND ELECTRICAL ENGINEERS in the Works Department of the Air Ministry, in connexion with the design, operation and maintenance of ground mechanical and electrical works services on R.A.F. stations at home and overseas and on Civil Aviation stations— The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.290/52A.

PHYSICISTS AND ENGINEERS (Principal Scientific Officer and Senior Scientific Officer grades) at Ministry of Supply London headquarters, for work concerned with the development of guidance and control systems and the application of specialist techniques including radio, radar and electronics to such systems—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.206/52A.

PROFESSOR OF TELECOMMUNICATION ENGINEERING under the Government of India—The Ministry of Labour and National Service (A.S.12), Almack House, 26 King Street, London, S.W.1, quoting A.12/ITU/193/52.

SOILS CHEMIST or PHYSICIST (postgraduate experience is essential), a CHEMICAL ENGINEER for research and advisory work, a PLANT PATHOLOGIST for research on diseases of Hevea, a PLANT PHYSIOLOGIST or BIOCHEMIST to study the physiology of latex formation, a BOTANIST to work in Malaya and America on the taxonomy of Hevea, a BOTANIST for preliminary training in the United Kingdom in soil microbiology prior to work in Malaya, a CHEMIST for preliminary training in the United Kingdom in microbiology and bacteriology prior to work in Malaya on rubber latex, and an AGRICULTURIST (graduate) for Smallholders' Advisory Service, in the Rubber Research Institute of Malaya, Kuala Lumpur—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, South Kensington, London, S.W.7.

TECHNICAL AND RESEARCH ASSISTANT (honours graduate in oceanography, meteorology, general physics or mathematics) for subjects related to tides—The Director, The Observatory, Birkenhead.

WOOL TEXTILE RESEARCH COUNCIL FELLOWSHIPS : (*a*) in Organic Chemistry, for work on the chemistry of the wool fibre and allied materials, (*b*) in Physics or Physical Chemistry, for work on the structure of wool and related fibres—The Principal, Technical College, Bradford.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Annual Report of the Royal Zoological Society of Scotland for the Financial Year ending 31st December 1951. Pp. 24. (Edinburgh : Royal Zoological Society of Scotland, 1952.) [125

Philosophical Transactions of the Royal Society of London. Series A : Mathematical and Physical Sciences. No. 888, Vol. 244 : Large Elastic Deformations of Isotropic Materials, 9, The Deformation of Thin Shells. By J. E. Adkins and R. S. Rivlin. Pp. 505–531. (London : Cambridge University Press, 1952.) 6*s.* 6*d.* [125

Philosophical Transactions of the Royal Society of London. Series B : Biological Sciences. No. 634, Vol. 236 : On the Nervous System of Saccoglossus cambrensis (Enteropneusta). By E. W. Knight-Jones. Pp. 315–354 + plates 32–35. 15*s.* No. 635, Vol. 236 : Water Movements in Lakes during Summer Stratification ; Evidence from the Distribution of Temperature in Windermere. By Dr. C. H. Mortimer. Pp. 355–404. 11*s.* 6*d.* (London : Cambridge University Press, 1952.) [125

Other Countries

The Selection of Military Manpower : a Symposium. Edited by Leonard Carmichael and Prof. Leonard C. Mead. (Publication 269.) Pp. vii + 269. (Washington, D.C. : National Research Council, 1951.) 2.50 dollars. [85

World Health Organization. Technical Report Series No. 50 : Expert Committee on the International Pharmacopœia ; Ninth Report, including Third Report of the Subcommittee on Non-Proprietary Names. Pp. 33. (Geneva : World Health Organization ; London : H.M. Stationery Office, 1952.) 2*s.* ; 25 cents ; 1 Swiss franc. [125

World Health Organization. Second Seminar for European Sanitary Engineers, Rome, 11–17 November 1951. Pp. v + 280. (Geneva : World Health Organization, 1952.) [125